



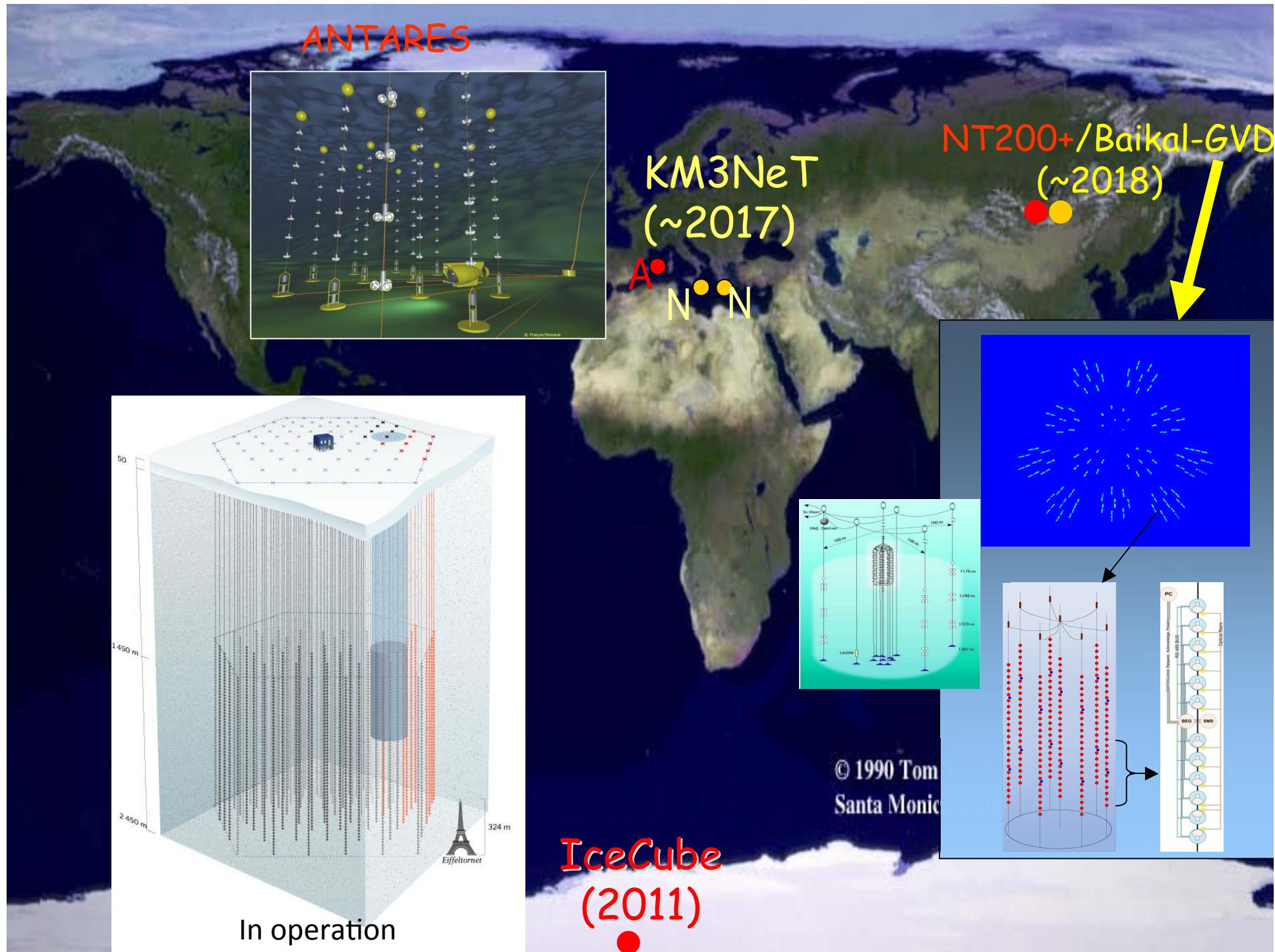
3rd Roma International Conference on Astro-particle Physics

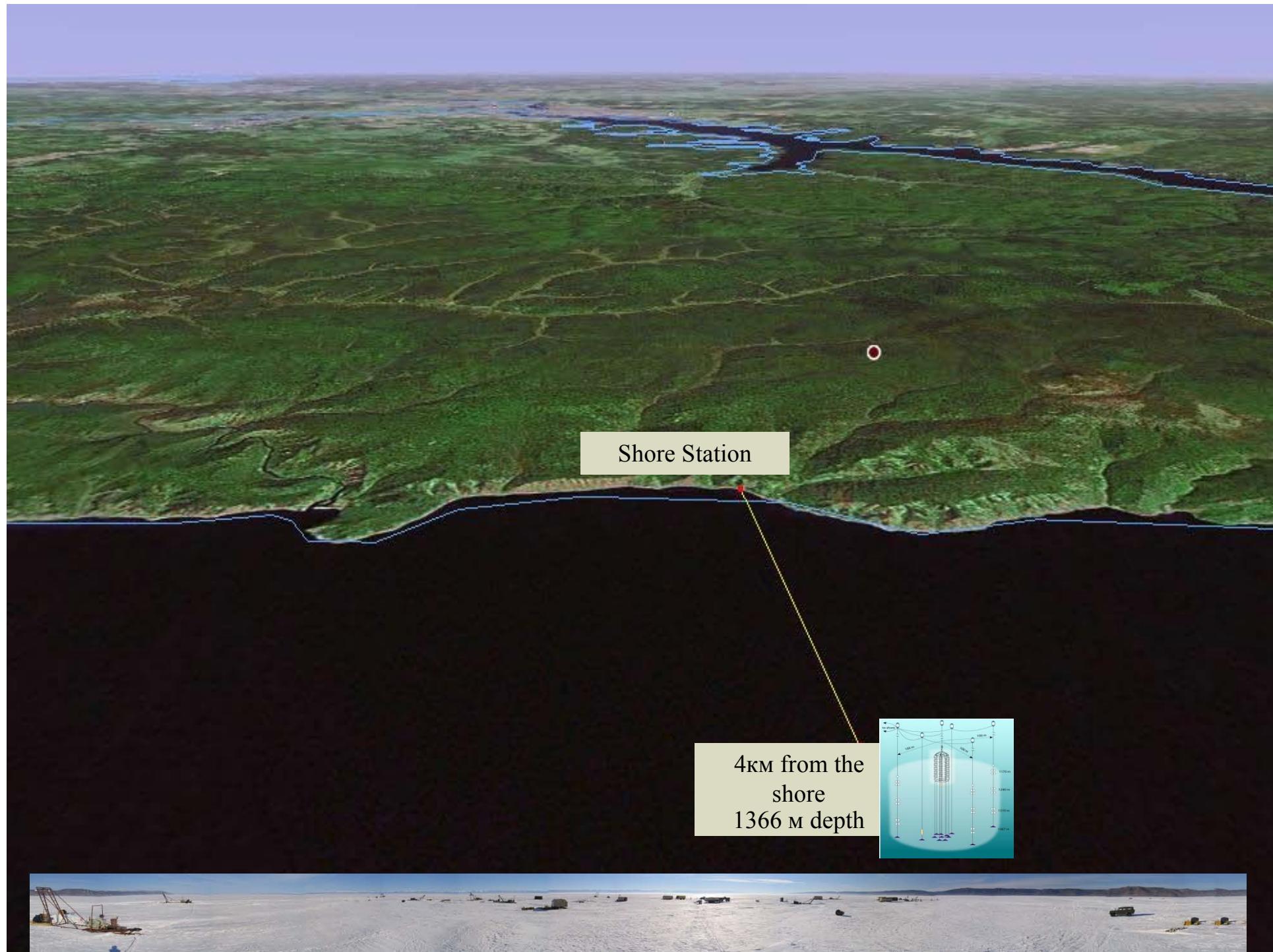
25-27 May 2011
Roma Italy

Status of the BAIKAL-GVD Project

**Zh.-A. Dzhilkibaev (INR, Moscow)
for the Baikal Collaboration**

Rome, May 26, 2011

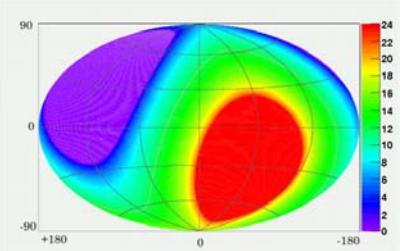
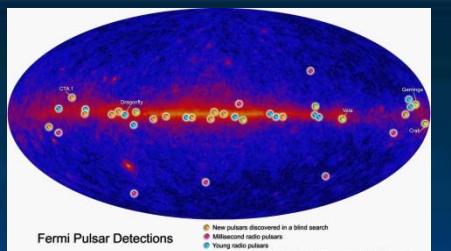




Site properties

- **Location:**

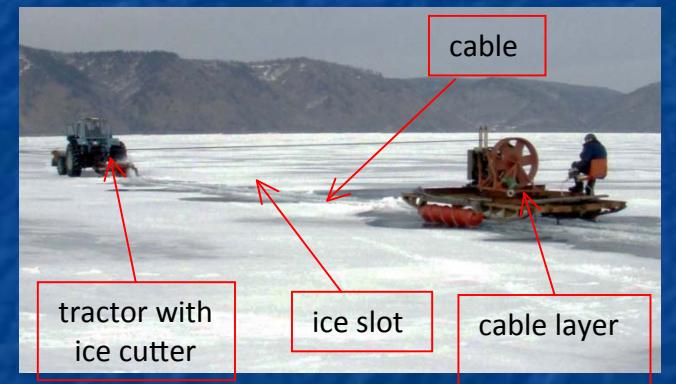
- Northern hemisphere – GC ($\sim 18\text{h/day}$) and Galactic Plane survey
- Flat 1350 m depth Lake bed (>3 km from the shore) – allows $\sim 30 \text{ km}^3$ Instr. Volume!



- **Strong ice cover during ~ 2 months:**

- Telescope installation, maintenance, upgrade and rearrangement
- Installation & test of a new equipment
- All connections are done on dry
- Fast shore cable installation (3-4 days)

Shore cable deployment



- **Water optical properties:**

- Absorption length – 22-24 m
- Scattering length: 30-50 m ($L_{\text{eff}} \sim 300-500$ m)
- Moderately low background in fresh water

Water properties allow detection of all flavor neutrinos with high direction-energy resolution!

Baikal - Milestones

Since 1980 Site tests and early R&D started

1990 Technical Design Report NT200

1993 NT36 started: - the first underwater array
- the first neutrino events.

1998 NT200 commissioned: start full physics program

2005 NT200+ commissioned (NT200 & 3 outer strings)

2006 Start R&D towards the Gigaton Volume Detector (GVD)

2008-10 In-situ test of the GVD electronics: Prototype strings

2011 Prototype cluster (3 strings), Technical Design Report



Gigaton Volume Detector (GVD) in Lake Baikal

R&D status

Objectives:

- km3-scale 3D-array of photodetectors
- flexible structure allowing an upgrade and/or a rearrangement of the main building blocks (clusters)
- high sensitivity and resolution of neutrino energy, direction and flavor content

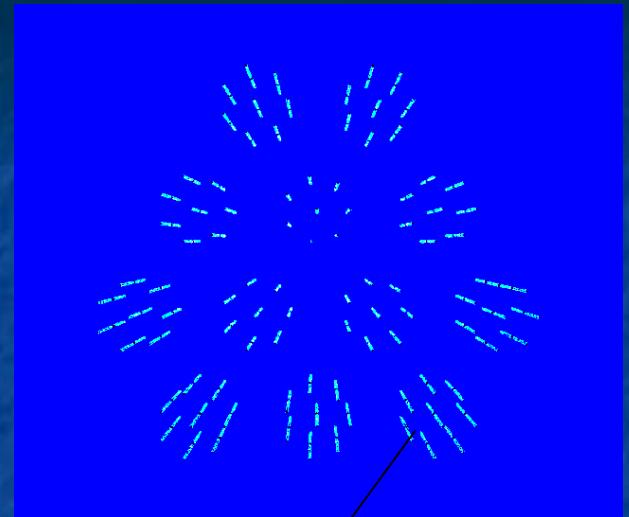
Central Physics Goals:

- Investigate Galactic and extragalactic neutrino “point sources” in energy range $> 3 \text{ TeV}$
- Diffuse neutrino flux – energy spectrum, local and global anisotropy, flavor content
- Transient sources (GRB, ...)
- Dark matter – indirect search
- Exotic particles – monopoles, Q-balls, nuclearites, ...

GVD - basic design

Layout:

-2304 Optical Modules, 96 Strings, 12 Clusters.
String comprises 24 OMs, which are combined in
2 independent Sections.
Cluster contains 8 strings.



Instrumented volume: 0.3 km³

Detection Performance

Cascades: (E>100 TeV): $V_{\text{eff}} \sim 0.2\text{--}0.7 \text{ km}^3$

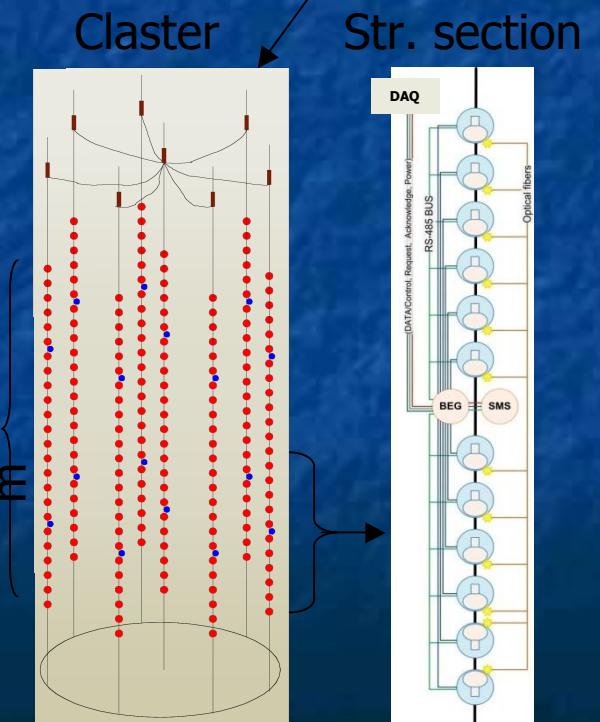
$$\delta(E/E_{\text{sh}}) \sim 25\%$$

$$\delta\theta_{\text{med}} \sim 5^\circ$$

Muons: (E>5 TeV): $S_{\text{eff}} \sim 0.2\text{--}0.8 \text{ km}^2$

$$\delta\theta_{\text{med}} \sim 0.5^\circ$$

$$\delta \lg(E/E_\mu) \sim 0.4$$



Optimisation of GVD configuration

Parameters for optimization:

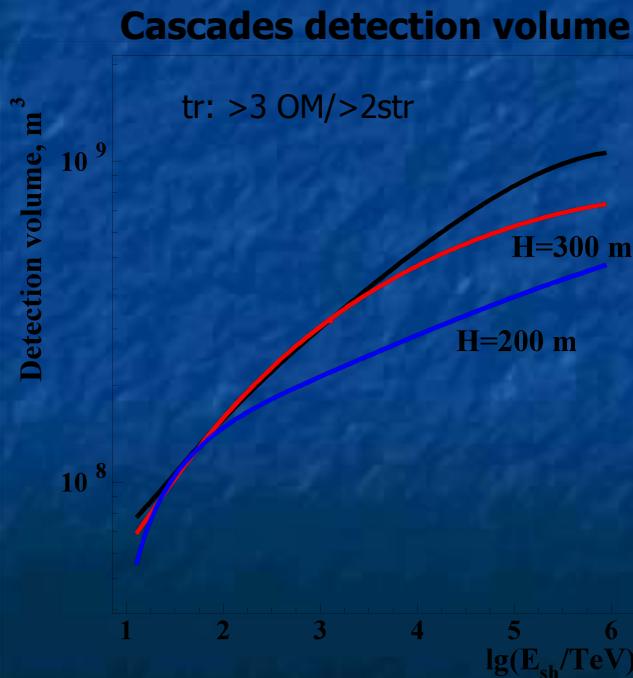
Z – vertical distance between OMs

R – distance between string and cluster centre

H – distance between centres of neighbouring clusters

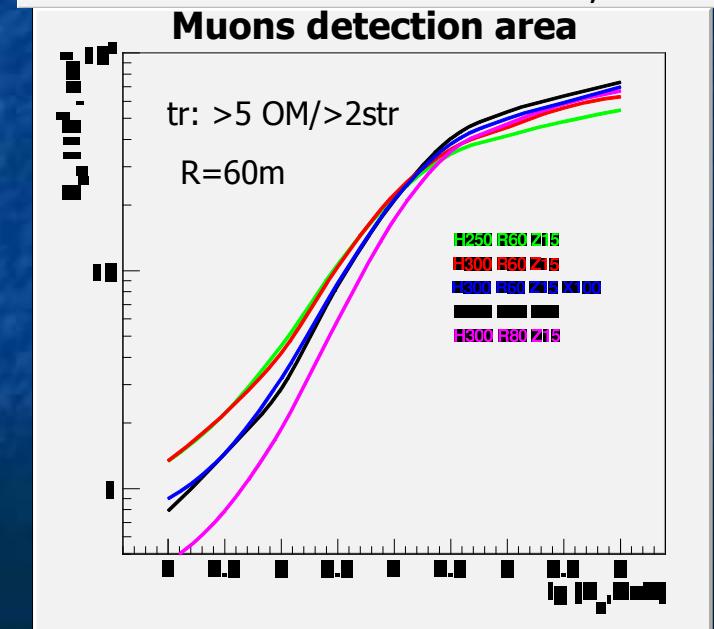
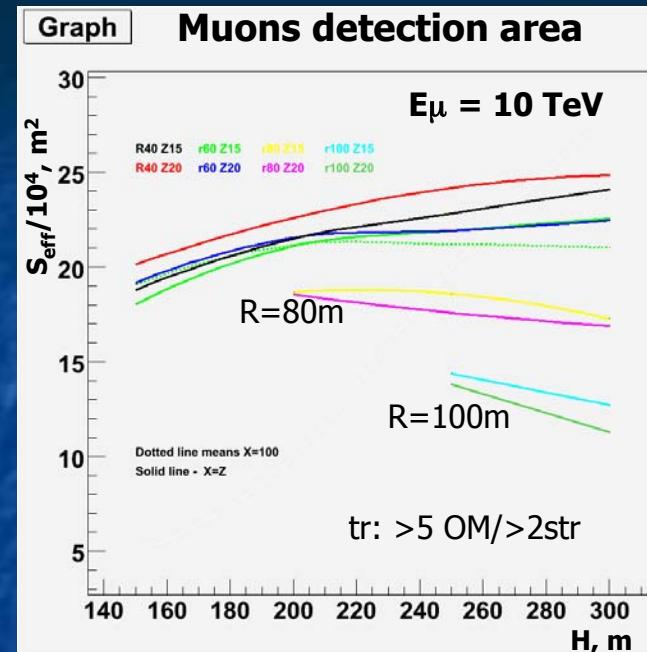
Trigger (cluster): coincidences of any neighbouring
OMs on string (thresholds 0.5&3p.e.)

PMT: R7081HQE, 10'', QE~0.35

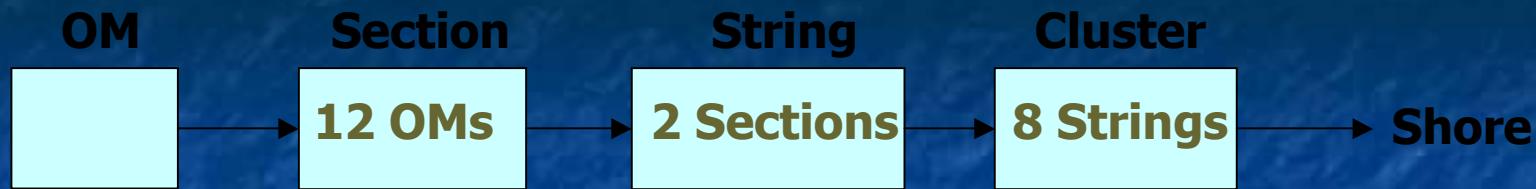


The compromise between
cascade detection volume
and muon effective area:

$H = 300\text{ m}$
 $R = 60\text{ m}$
 $Z = 15\text{ m}$



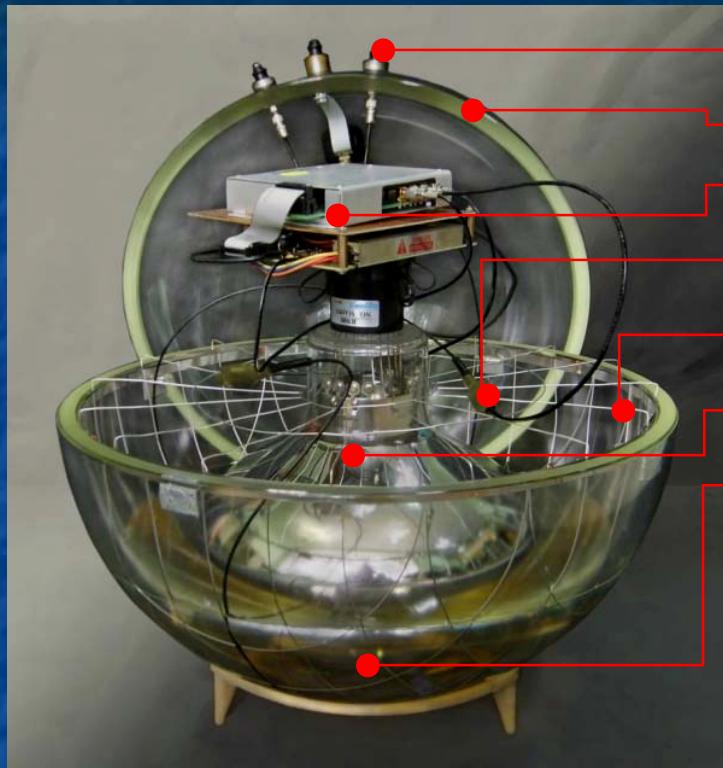
GVD – R&D (2006-2010)



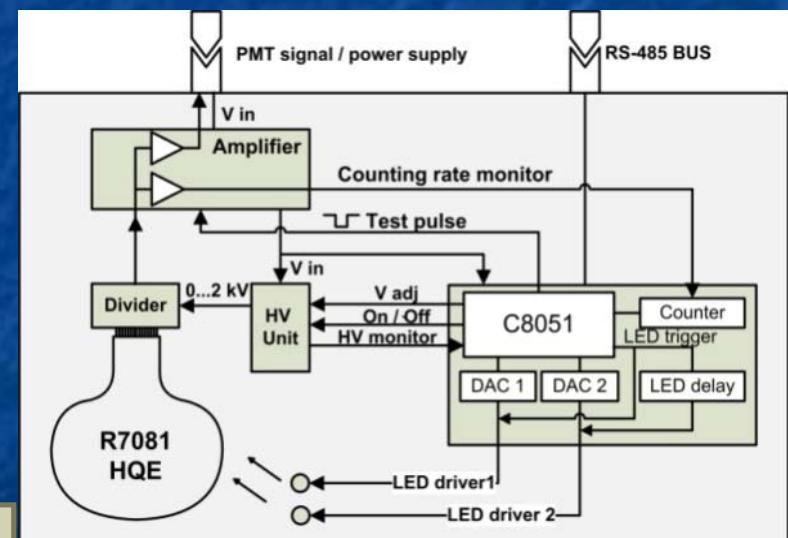
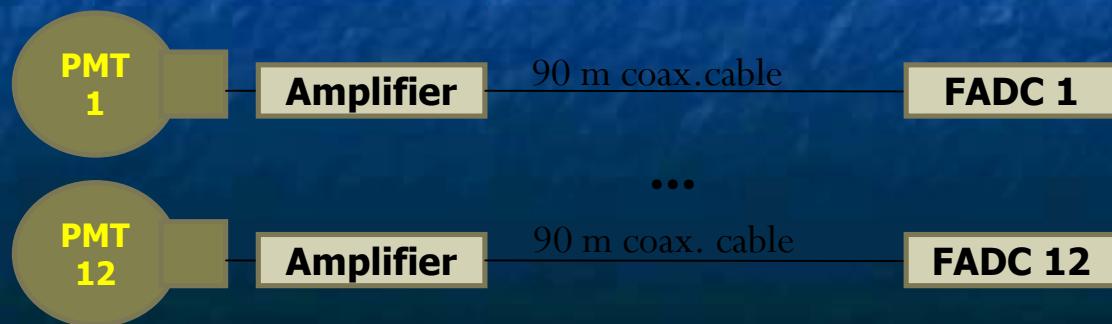
GVD - Key Elements and Systems:

- Optical Module
- FADC-readout system
- Section Trigger Logics
- Calibration
- Data Transport
- Cluster Trigger System, DAQ
- Data Transport to Shore

Optical module (OM)



Optical module with PM R7081HQE
OM



Functional scheme of the optical module
electronics

Section – basic detection unit

Section:

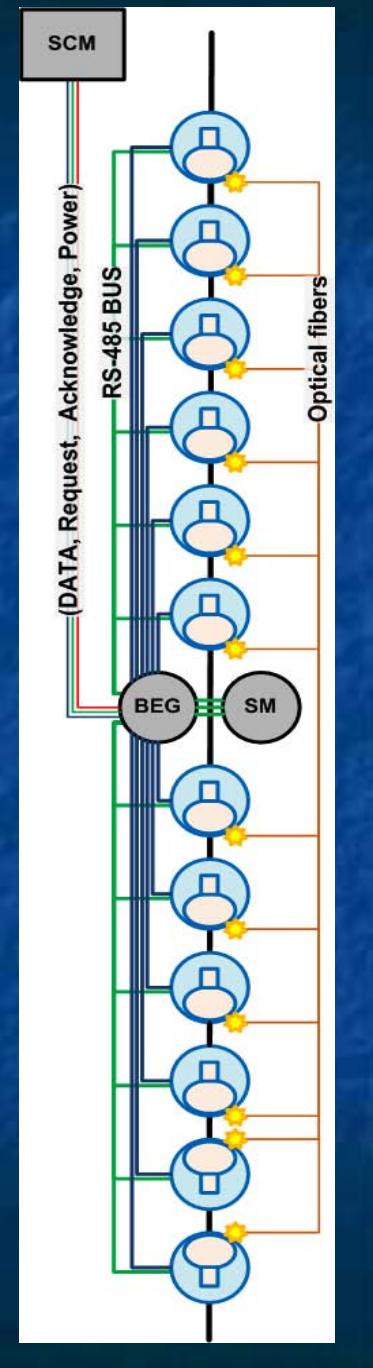
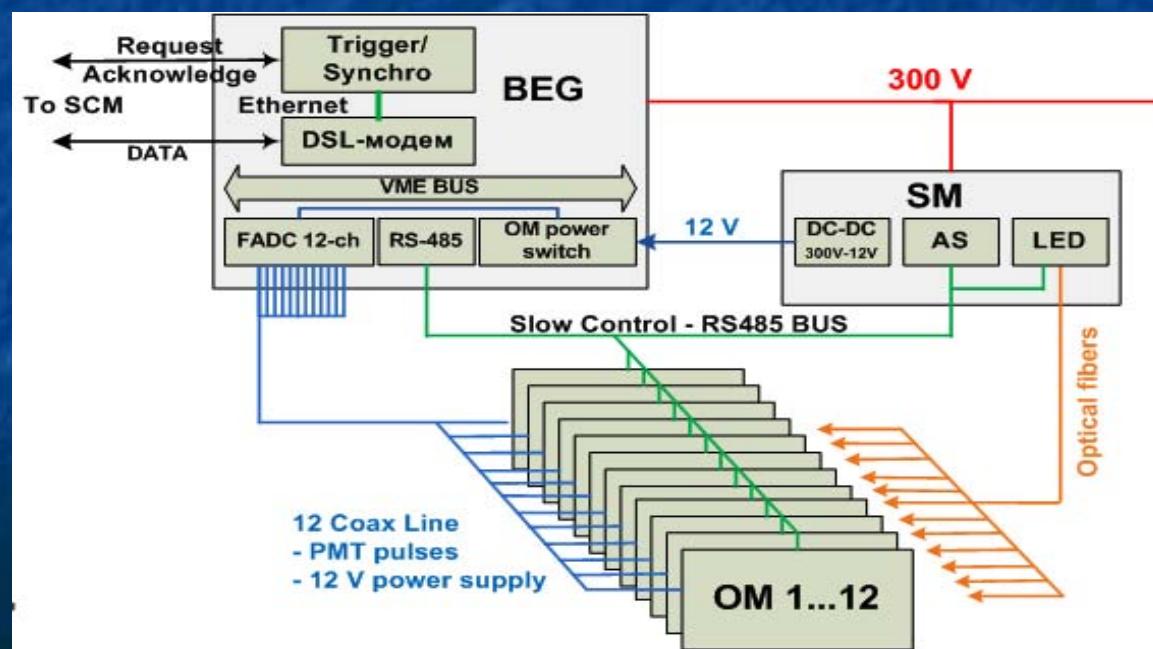
- 12 Optical Modules
- BEG with 12 FADC channels and trigger unit
- Service Module (SM): LEDs for OM calibration, OM power supply, acoustic positioning system.

Basic trigger: coincidences of nearby OM (threch. $\sim 0.5\&3$ p.e.)
expected count rate < 100 Hz

Communications:

BEG \leftrightarrow cluster centre: DSL-modem, expected dataflow < 1 Mbit/s

BEG \leftrightarrow OMs: RS-485 Bus (slow control)



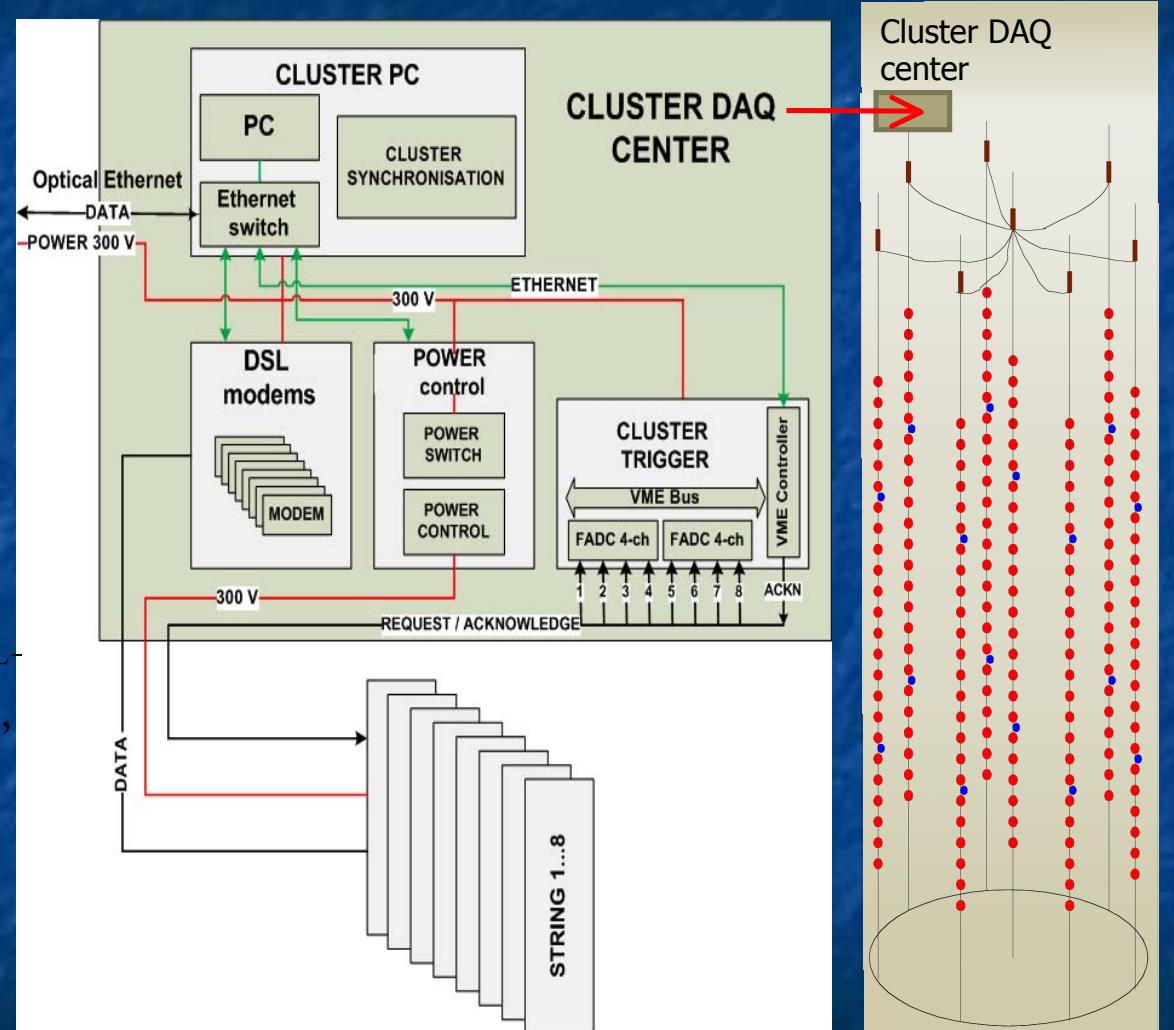
Cluster of strings

8 Strings

String consists of 2 sections
 $(2 \times 12 \text{ OM})$

Cluster DAQ Centre (4 modules)

1. PC-module with optical Ethernet communication to shore (data transmission and synchronization)
2. Trigger module with 8 FADC channels (time mark of string trigger)
3. Data communication module (8 DSL modems for communication to strings, $\sim 10 \text{ Mbit/s}$ for 1 km)
4. Power control system

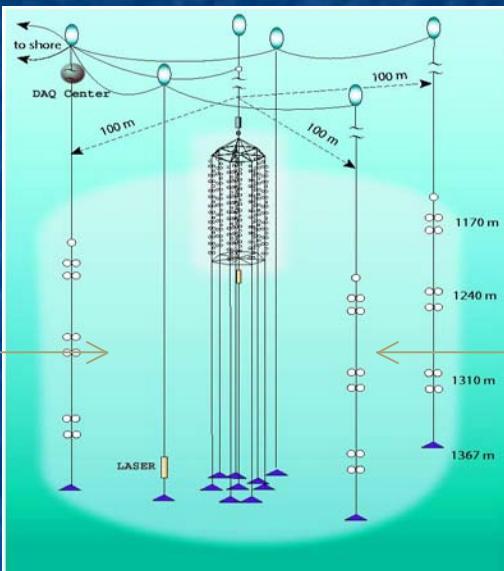
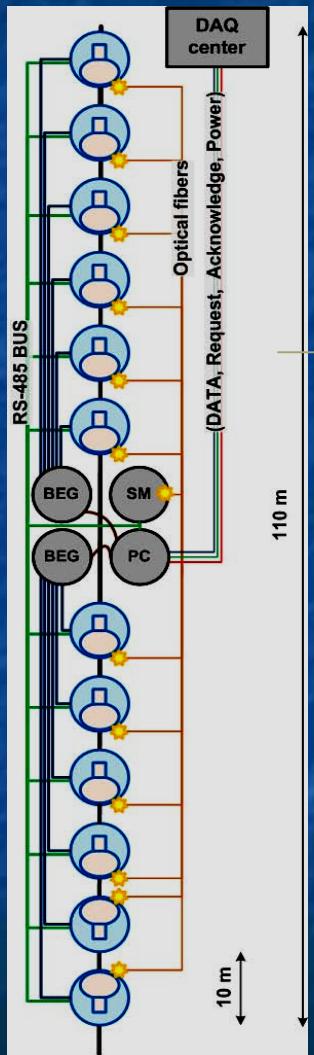


GVD prototype strings 2009 - 2010

Prototype string

2009

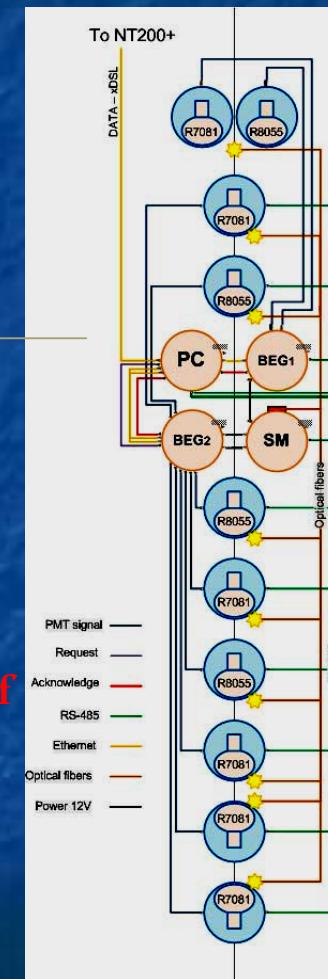
PMT:
Photonis
XP1807
6 OM
Hamamatsu
R8055
6 OM



Prototype string

2010

PMT:
Hamamatsu
R7081HQE
7 OM
Hamamatsu
R8055
3 OM

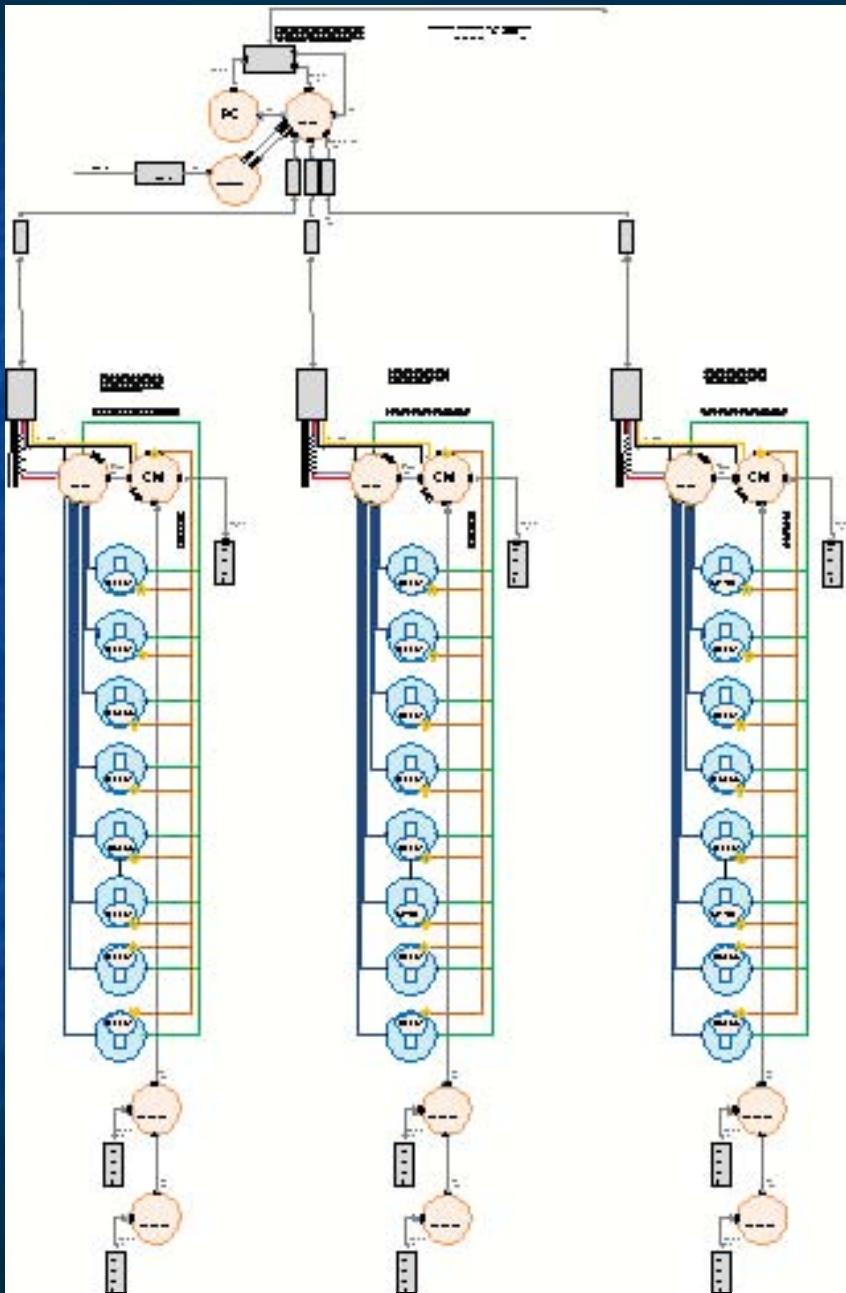


In-situ tests of basic elements of GVD with prototypes strings (2009...2010)

Investigation and tests of new optical modules, DAQ system, cabling system, triggering approaches

(LED Laser Muons)

Prototype Cluster - 2011



Optical modules

24 OM, R7081HQE (10") R8055 (13") XP1807 (12")

DAQ, control and calibration systems of the section

- 3 service modules
- 3 BEGs - 24 FADC

Cluster DAQ-center

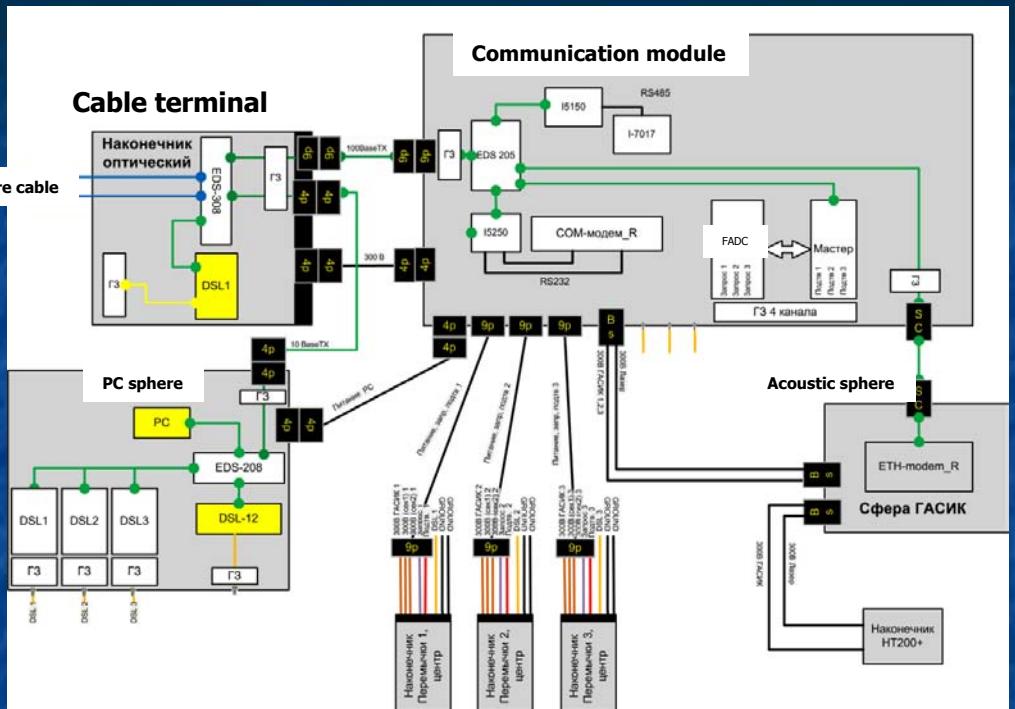
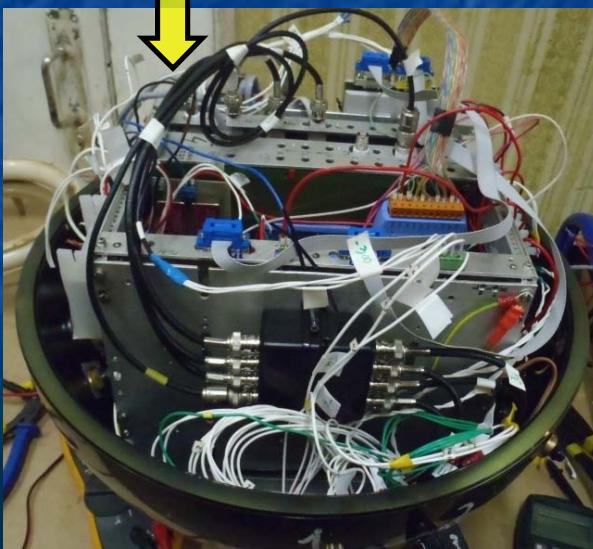
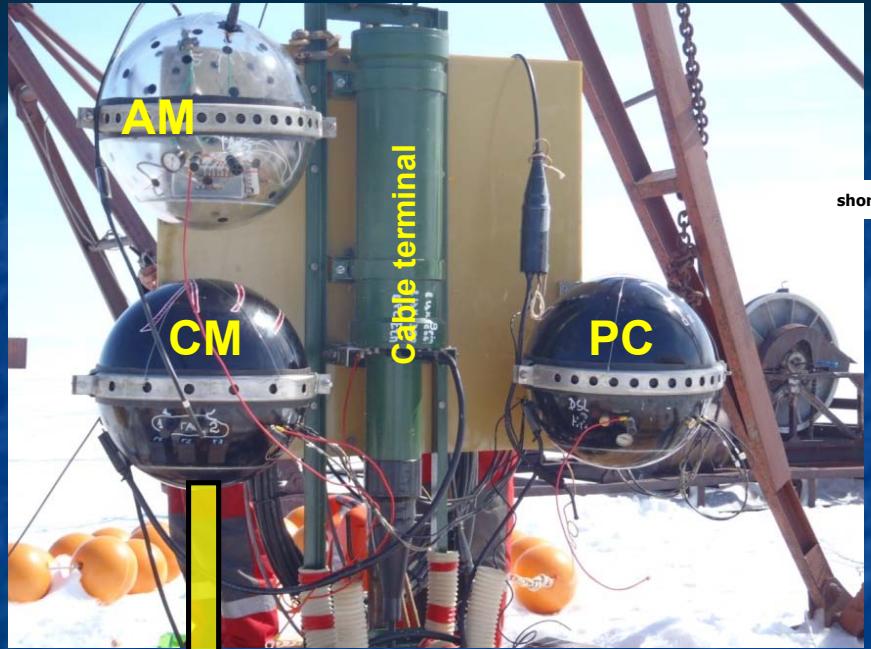
- Module of optical communication channel
- Underwater PC
- Commutation module
- Communication module of acoustic positioning system

Modules of alternative acoustic positioning system - 9 modules

Cables

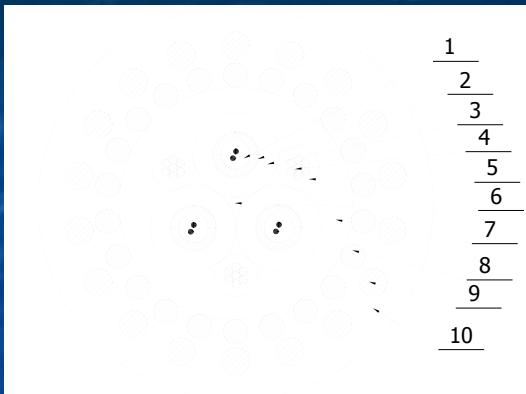
- To-shore electro-optical cable

Cluster DAQ-center

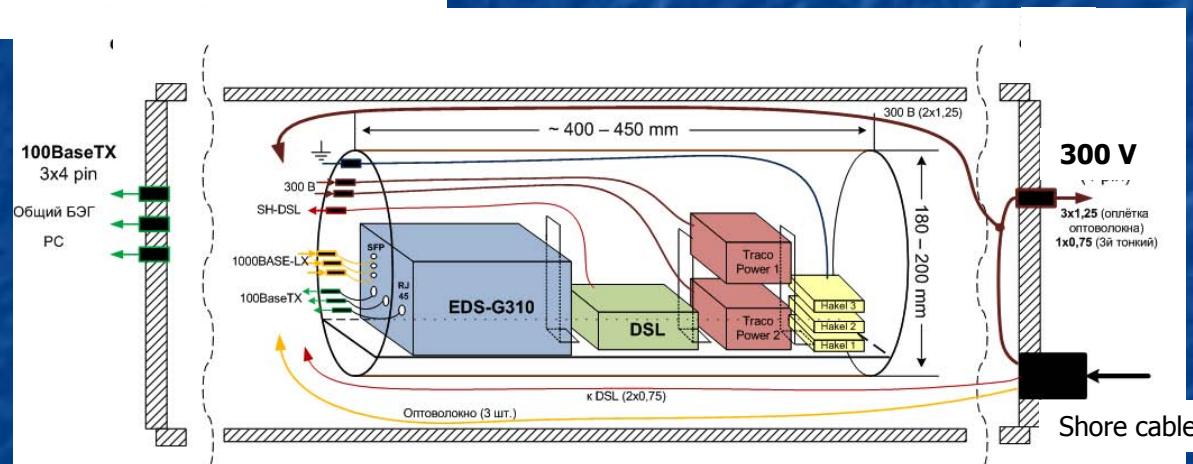


- **Communication Module (CM):** cluster trigger (4 FADC-200 MHz), strings power supply.
- **Underwater PC:** strings data transmission by DSL-modems.
- **AM:** communication module of acoustic positioning system
- **Module of optical communication channel**

GVD – shore connection



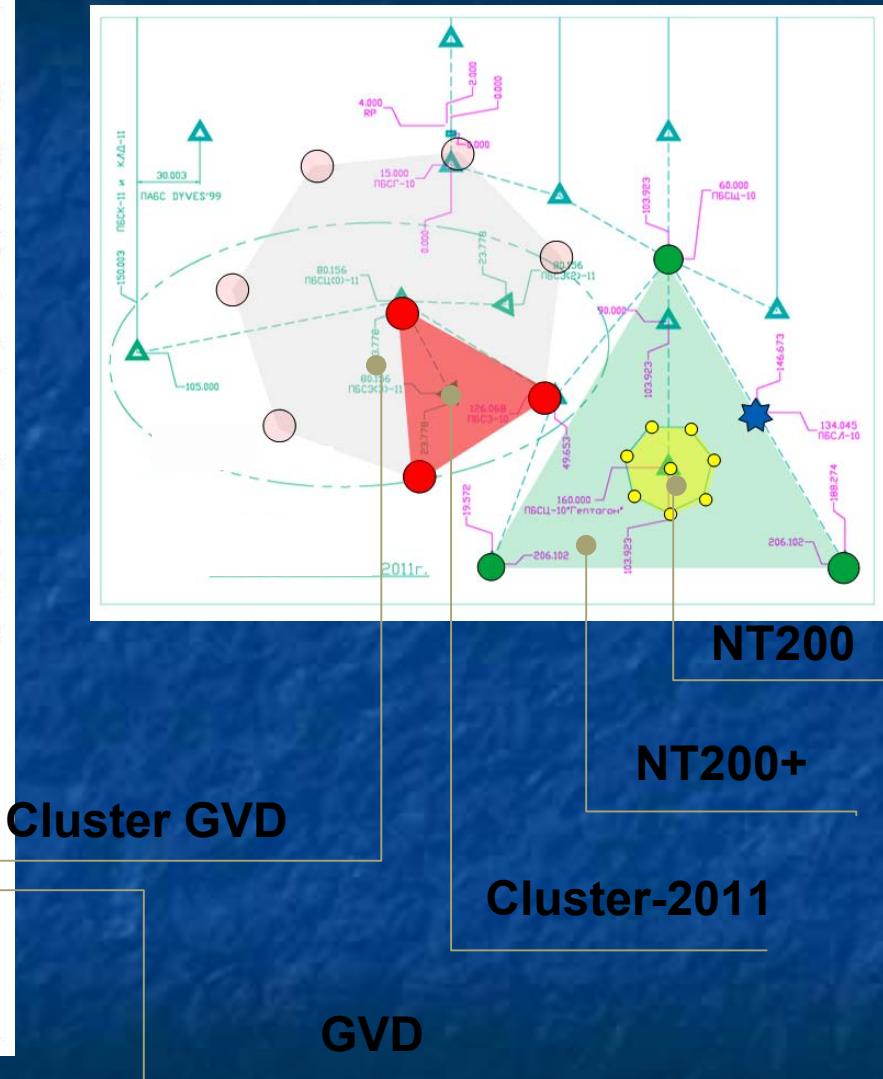
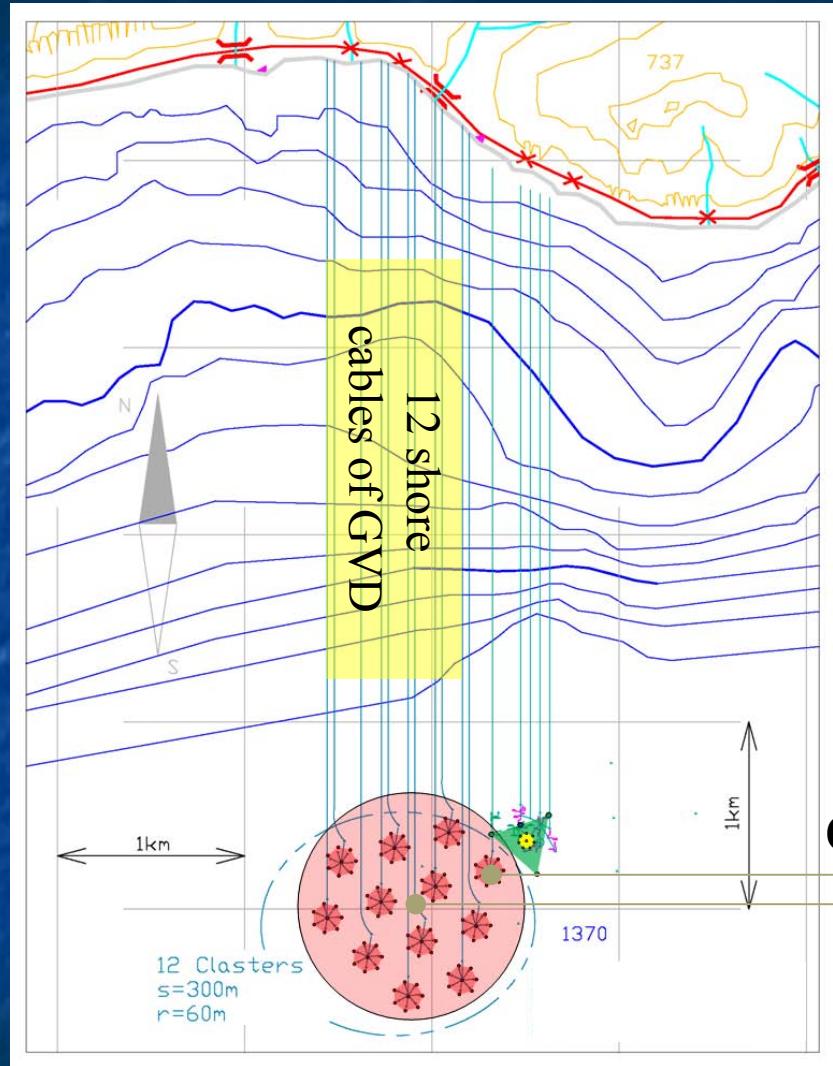
Deep underwater electro-optical cable
6 optical fibers, 6 copper leads.



Module of optical communication channel: 2 data transmission channels 1 Gbit/c (3 optical fibers), 3 reserve optical lines, voltage supply (DC-DC TracoPower, MTBF 3×10^6 hours).

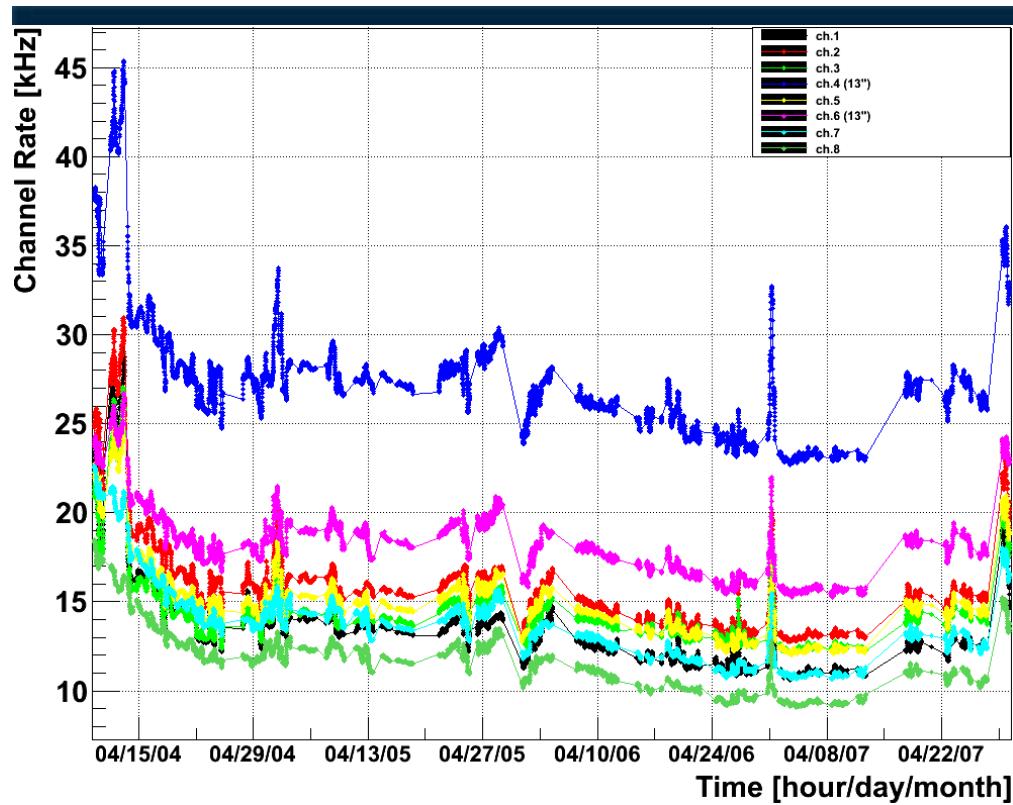


From NT200 to GVD – 2011 yr



Schedule:

- >2006 **Activity towards the GVD**
- 2008-10 **Prototype Strings** (test of key elements and systems)
- 2011 **Technical Design Report, Prototype cluster**
- 2012-14 **Prototyping/Construction Phase**
- 2012 **First string, upgrade of prototype cluster**
- 2014 **First Cluster/Data taking**
- 2014-18 **Construction/Data taking**



OMs counting rates

Time difference of two OMs signals
from atm. muons

