2nd Workshop on Very Large Volume Neutrino Telescopes (VLVvT2), Catania, Sicily, November 8-11, 2005

KM3NeT:

Towards a km³ Mediterranean Neutrino Telescope

Uli Katz Univ. Erlangen 09.11.2005

- Some Physics Arguments
- Aiming at a km³ Detector in the Mediterranean Sea
- The KM3NeT Design Study and Beyond
- Conclusions and Outlook

The Neutrino Telescope World Map



Neutrinos from Astrophysical Point Sources



Association of neutrinos to specific astrophysical objects.

- Energy spectrum, time structure, multi-messenger observations provide insight into physical processes inside source.
- Searches profit from very good angular resolution of water Čerenkov telescopes.
- km³ detectors needed to exploit full potential of neutrino astronomy.

Sky Coverage of Neutrino Telescopes



 \rightarrow We need ν telescopes in both hemispheres to see the whole sky

High-energy sources in the Galactic Center

- 5 sources could be/are associated with SNR, e.g. RX J1713.7;
- 3 could be pulsar wind nebulae, typically displaced from the pulsar;
- Some coincide with EGRET, ASCA, ... unidentified sources;
- 3 have no counterpart known to us.



W. Hofmann, ICRC 2005

Galactic Longitude (°)

Neutrinos from Supernova Remnants



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Arguments for a km³ Volume

Solid theoretical arguments indicate that a cubic kilometer is the right volume for detection of

- neutrinos from specific astrophysical accelerators (point sources);
- neutrinos from the cosmic distribution of all neutrino sources (diffuse flux);
- neutrinos produced in interactions of cosmic rays with the cosmic microwave background (cosmogenic neutrinos).

Aiming at a km³-Detector in the Mediterranean

HENAP Report to PaNAGIC, July 2002:

- "The observation of cosmic neutrinos above 100 GeV is of great scientific importance. ..."
- "... a km³-scale detector in the Northern hemisphere should be built to complement the IceCube detector being constructed at the South Pole."
- "The detector should be of km³-scale, the construction of which is considered technically feasible."

How to Design a km³ Deep-Sea v Telescope



Large volume with same number of PMs?

• PM distance:

given by absorption length in water (~60 m) and PM properties

Efficiency loss for larger spacing

Existing telescopes "times 30" ?

- Too expensive
- Too complicated: production & deployment takes forever, maintenance impossible
- Not scalable (readout bandwidth, power, ...)

R&D needed:

- Cost-effective solutions to reduce price/volume by factor 2-5
- Stability goal: maintenance-free detector
- Fast installation
 - time for construction & deployment less than detector life time
- Improved components

KM3NeT Design Study: Participants

- Cyprus: Univ. Cyprus
- France: CEA/Saclay, CNRS/IN2P3 (CPP Marseille, IreS Strasbourg, APC Paris-7), Univ. Mulhouse/GRPHE, IFREMER
- Germany: Univ. Erlangen, Univ. Kiel
- <u>Greece</u>: HCMR, Hellenic Open Univ., NCSR Demokritos, NOA/Nestor, Univ. Athens
- <u>Italy</u>: CNR/ISMAR, INFN (Univs. Bari, Bologna, Catania, Genova, Napoli, Pisa, Roma-1, LNS Catania, LNF Frascati), INGV, Tecnomare SpA
- <u>Netherlands</u>: NIKHEF/FOM (incl. Univ. Amsterdam, Univ. Utrecht, KVI Groningen)
- Spain: IFIC/CSIC Valencia, Univ. Valencia, UP Valencia
- UNIV. Aberdeen, Univ. Leeds, Univ. Liverpool, Univ. Sheffield

Particle/Astroparticle institutes (29) – Sea science/technology institutes (7) – Coordinator

KM3NeT Design Study: History . . .

Design Study for a Deep-Sea Facility in the Mediterranean for Neutrino Astronomy and Associated Sciences

- Initial initiative Sept. 2002.
- VLVvT Workshop, Amsterdam, Oct. 2003.
- ApPEC review, Nov. 2003.
- Inclusion of marine science/technology institutes (Jan. 2004).
- Proposal submitted to EU 04.03.2004.
- Evaluation report received June 2004 (overall mark: 88%).
- Confirmation that Design Study will be funded (Sept. 2004).
- Invitation to negotiations with EU Commission (July 2005).
- Submission of "negotiation documents" 30.09.2005
- Ind VLVvT Workshop, Catania, 08-11.11.2005

. . . and Presence

Message received from Brussels yesterday noon: "The KM3NeT contract will be produced now and should be sent to you within 2 weeks for signature"

- Negotiations are successfully concluded.
- The EU will fund the KM3NeT Design Study with 9 million €.
- Total volume ~20 million €, ~370 person-years.
- Start date: February 1, 2006.
- Major objectives:
 - Conceptual Design Report by summer 2007;
 - Technical Design Report by February 2009.

Objectives and Scope of the Design Study

Establish path from current projects to KM3NeT:

- Critical review of current technical solutions;
- New developments, thorough tests;
- Comparative study of candidate sites (figure of merit: physics sensitivity / €);
- Assessment of quality control and assurance;
- Exploration of links to industry;
- Investigation of funding and governance models.

Envisaged time scale of design, construction and operation poses stringent conditions.

Some Key Questions

 Which architecture to use? (strings vs. towers vs. new design) All these questions are highly interconnected !

- How to get the data to shore? (optical vs. electric, electronics off-shore or on-shore)
- How to calibrate the detector? (separate calibration and detection units?)
- Design of photo-detection units? (large vs. several small PMs, directionality, ...)
- Deployment technology? (dry vs. wet by ROV/AUV vs. wet from surface)
- And finally: path to site decision

The KM3NeT Design Study Work Packages

- WP1: Management of the Design Study
- WP2: Physics analysis and simulation
- WP3: System and product engineering
- WP4: Information technology
- WP5: Shore and deep-sea infrstructure
- WP6: Sea surface infrastructure
- WP7: Risk assessment and quality assurance
- WP8: Resource exploration
- WP9: Associated sciences

Detector Architecture

(D. Zaborov at VLV_VT)



Sea Operations

- Rigid towers or flexible strings?
- Connection in air (no ROVs) or wet mateable connectors?
- Deployment from platform or boat?



Photo Detection: Options

- Large photocathode area with arrays of small PMs packed into pressure housings - low cost!
- Determination of photon direction, e.g. via multi-anodic PMs plus a matrix of Winston cones.
- But: phase space for developments from scratch is too tight.









Photo Detection: Requirements





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KM3NeT: Political Environment

ESFRI (European Strategy Forum on Research Infrastructures)

- Charge: Assess future research infrastructures in Europe.
- KM3NeT is on the *List of Opportunities* (first step).
- Now: Evaluation of projects by expert groups; KM3NeT belongs to Astrophysics and Astroparticles (→presentation on Nov. 24, 2005).
- Further steps: Road Map and List of Priorities.

EU

- Views KM3NeT as a long-term project; the Design Study is only the first step towards preparation, construction and exploitation.
- The necessary political steps are to be initiated by the proponents in the Design Study phase.
- National support reinforced in several countries.

KM3NeT: Towards a Site Decision

- Final site decision involves scientific and political arguments (funding, host country support, ...).
- Objective of Design Study: Provide scientific input and stimulate political discussion.
- Possible scenario: Similar to Pierre Auger Observatory (two candidate sites, decision based on commitment of host country).
- Relation of funding options to site choice will be explored in Design Study.

KM3NeT: Path to Completion

Time scale given by "community lifetime" and the objective to take data concurrently with IceCube

Time schedule (partly speculative & optimistic):

01.02.2006 Mid-2007 February 2009 2009-2010 2010-2012 2011-20xx Start of Design Study Conceptual Design Report Technical Design Report Preparation Phase (possibly in FP7) Construction Data taking

Conclusions and Outlook

- Compelling scientific arguments for complementing IceCube with a km³-scale detector in the Northern Hemisphere.
- The Mediterranean-Sea neutrino telescope groups NESTOR, ANTARES and NEMO comprise the leading expertise in this field. They have united their efforts to prepare together the future, km³-scale deep-sea detector.
- An EU-funded Design Study (KM3NeT) will provide substantial resources for an intense 3-year R&D phase; start on February 1, 2006.
- Major objective: Technical Design Report by Feb. 2009.