13th Lomonosov Conference on
Elementary Particle Physics
Moscow, August 23 – 29, 2007

Acoustic Particle Detection and the ANTARES Neutrino Telescope

Topics:

- Astroparticle Physics with Neutrinos
- ANTARES Neutrino Telescope
- Acoustic Detection of Neutrinos

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Astroparticle Physics with (U)HE Neutrinos

Neutrino Oscillations:
Direction, Energy, Flavor

Dark matter search (WIMPs):
Direction, Energy

Low-energy limit:
- detector sensitivity
- background

Astrophysical point sources:
Direction, (Energy), Time

Diffuse cosmic neutrino flux:
(Direction), Energy

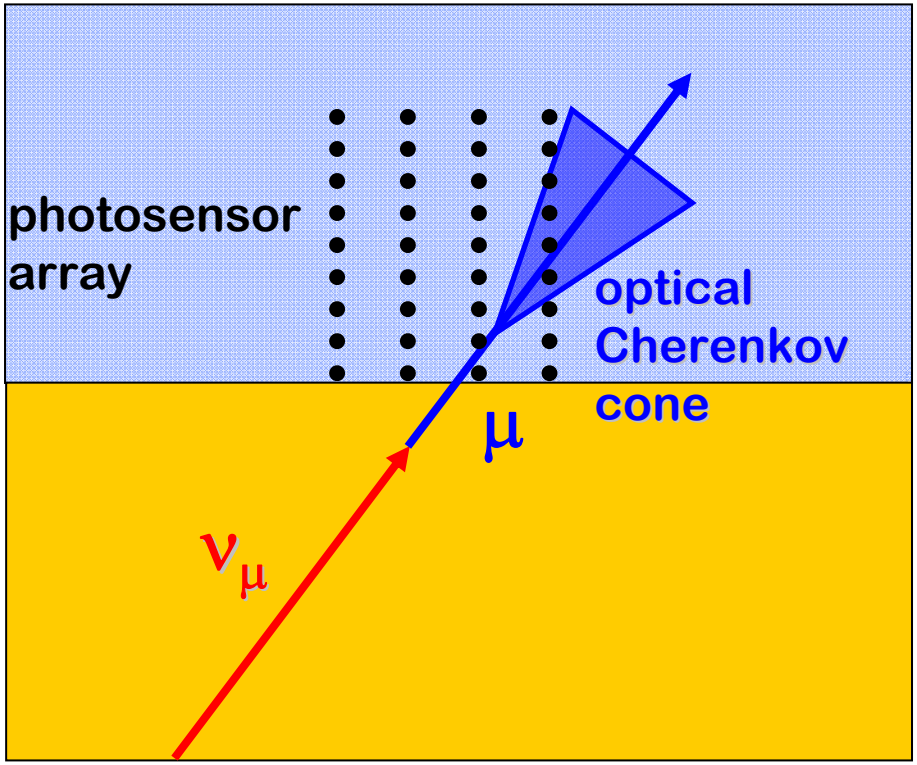
High-energy limit:
- neutrino flux decreases like E^{-n} ($n \approx 2$)
- large detection volume needed

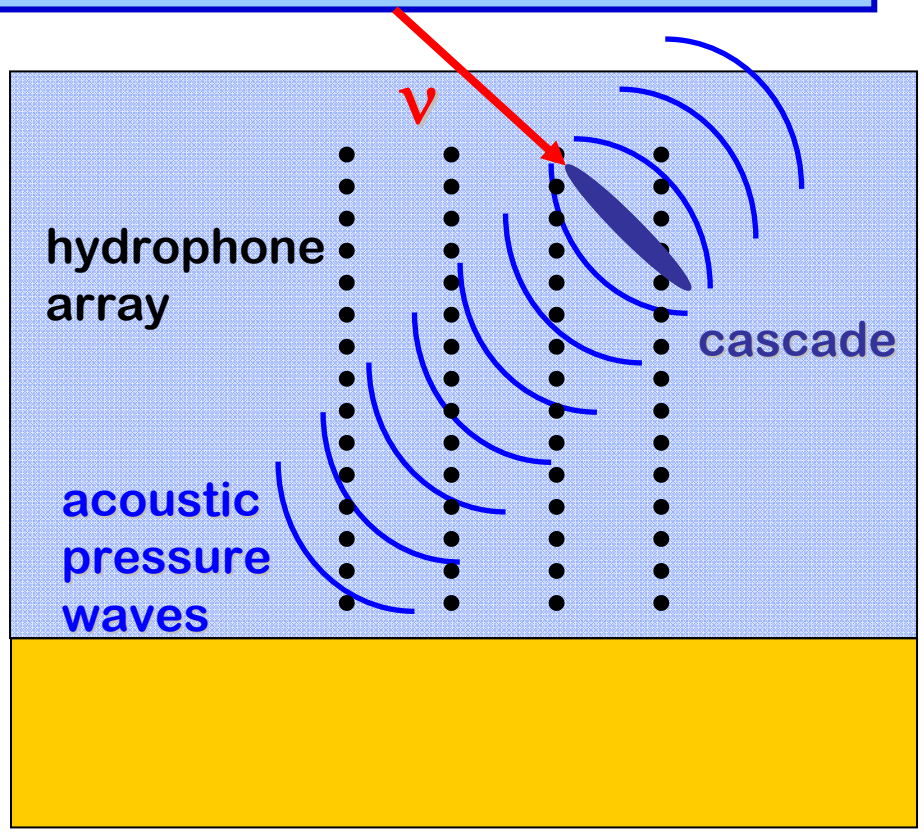
... and also: GZK neutrinos
Z bursts ...

optical Cherenkov telescopes:
Baikal, IceCube, ANTARES, ...

new techniques: radio, acoustics, ...
(many experiments)

Two (U)HE ν Detection Methods





Optical Cherenkov detector

established technology

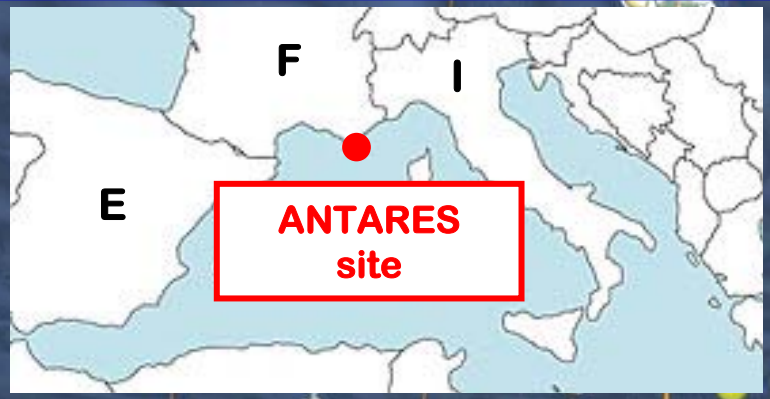
- photosensors
- attenuation order 50m to 100m (blue
- medium: water, ice

Acoustic detector

feasibility studies

- hydrophones
- very long lengths (of order
- medium: water, ice and sa

The ANTARES Neutrino Telescope



25 storeys,
350 m

Junction Box

- string-based detector (Lines)
- [1] 0.1 km^2 geometric area
- downward-looking photomultipliers (PMs), axis at 45° to vertical
- 2400 m water depth
- 25 km off shore

Current Status and Plans

Full detector:
12 Lines with 900 PMs

1 Instrumentation Line (IL)
for environment monitoring

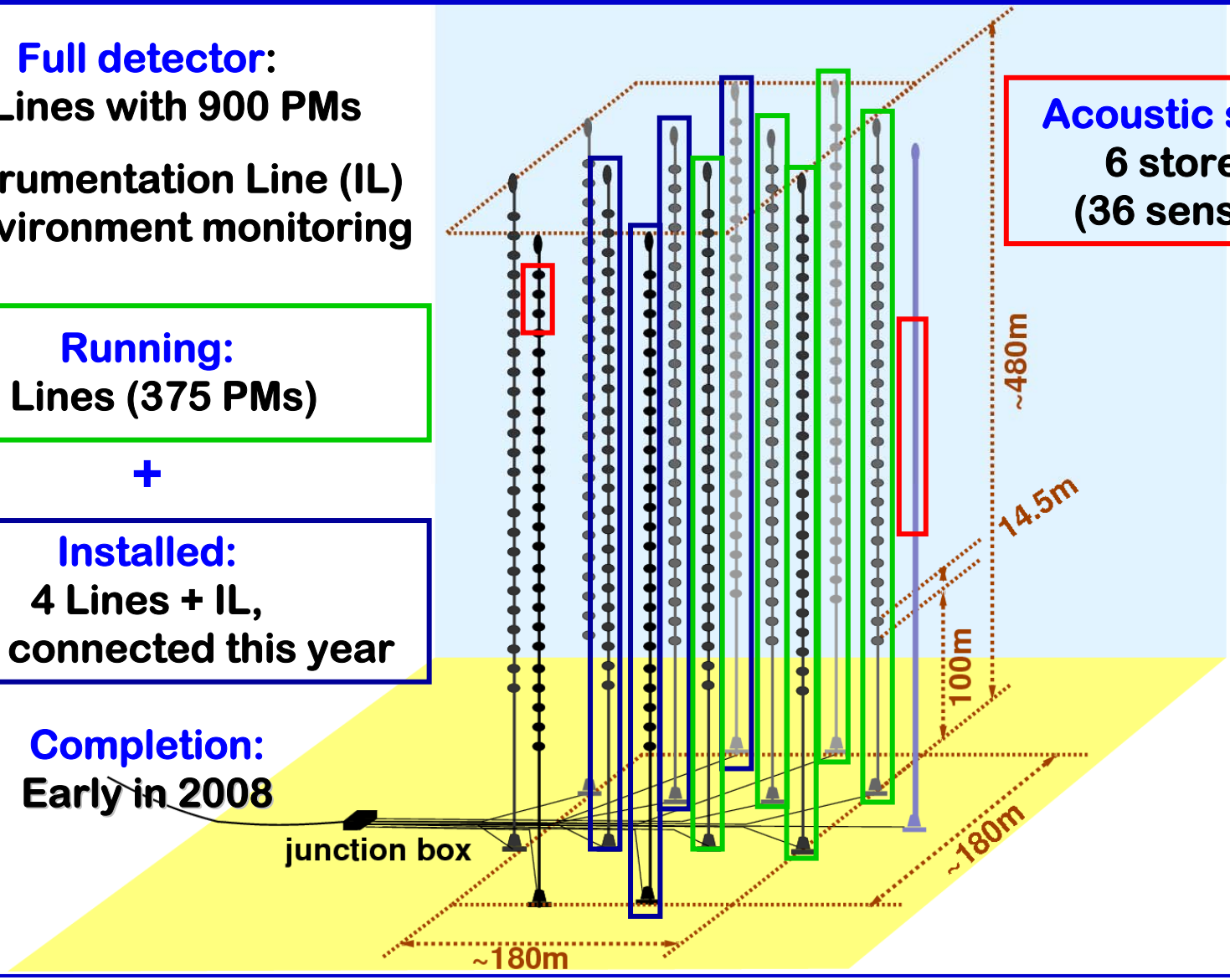
Running:
5 Lines (375 PMs)

+

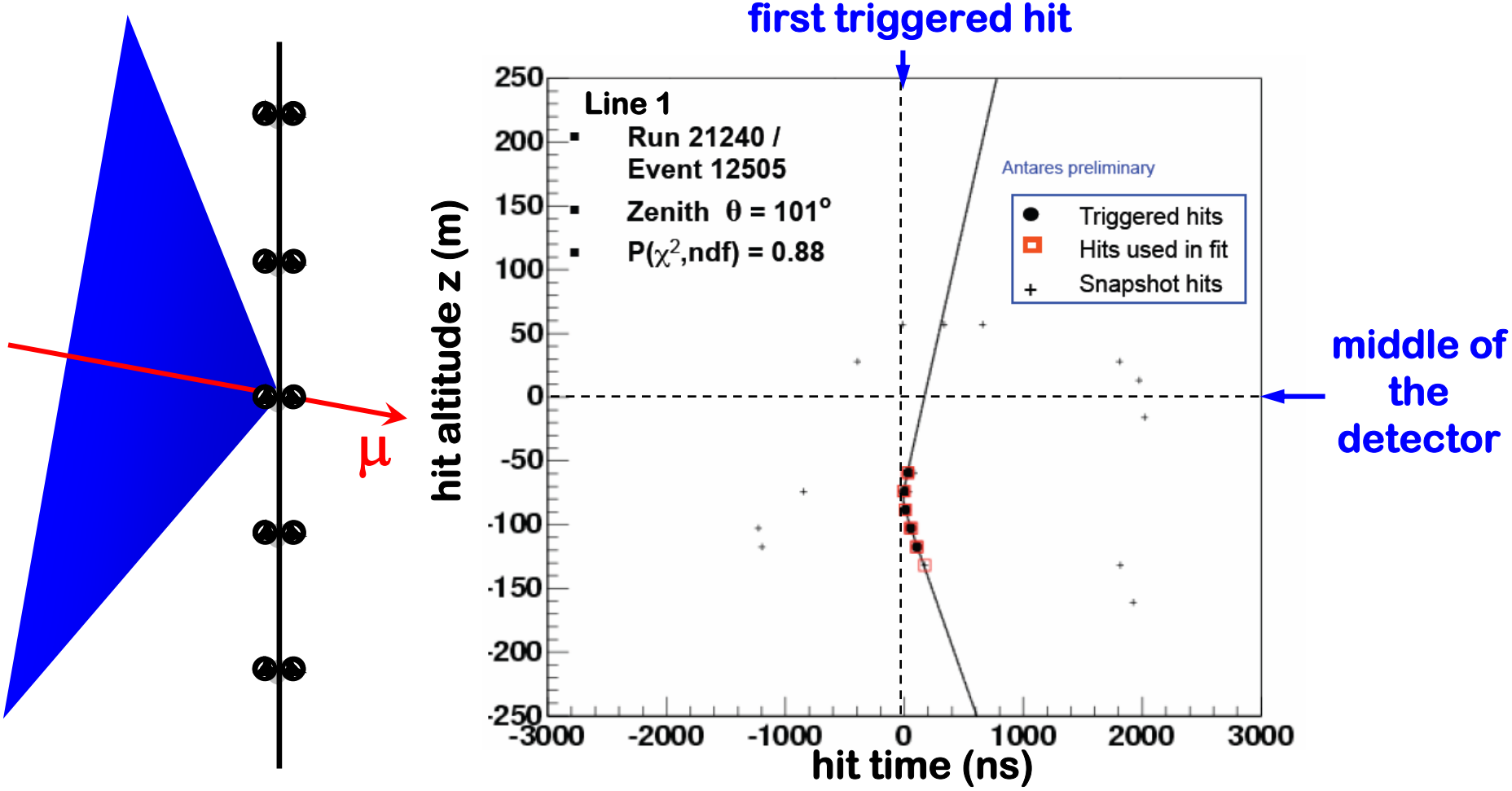
Installed:
4 Lines + IL,
to be connected this year

Completion:
Early in 2008

Acoustic setup:
6 storeys
(36 sensors)

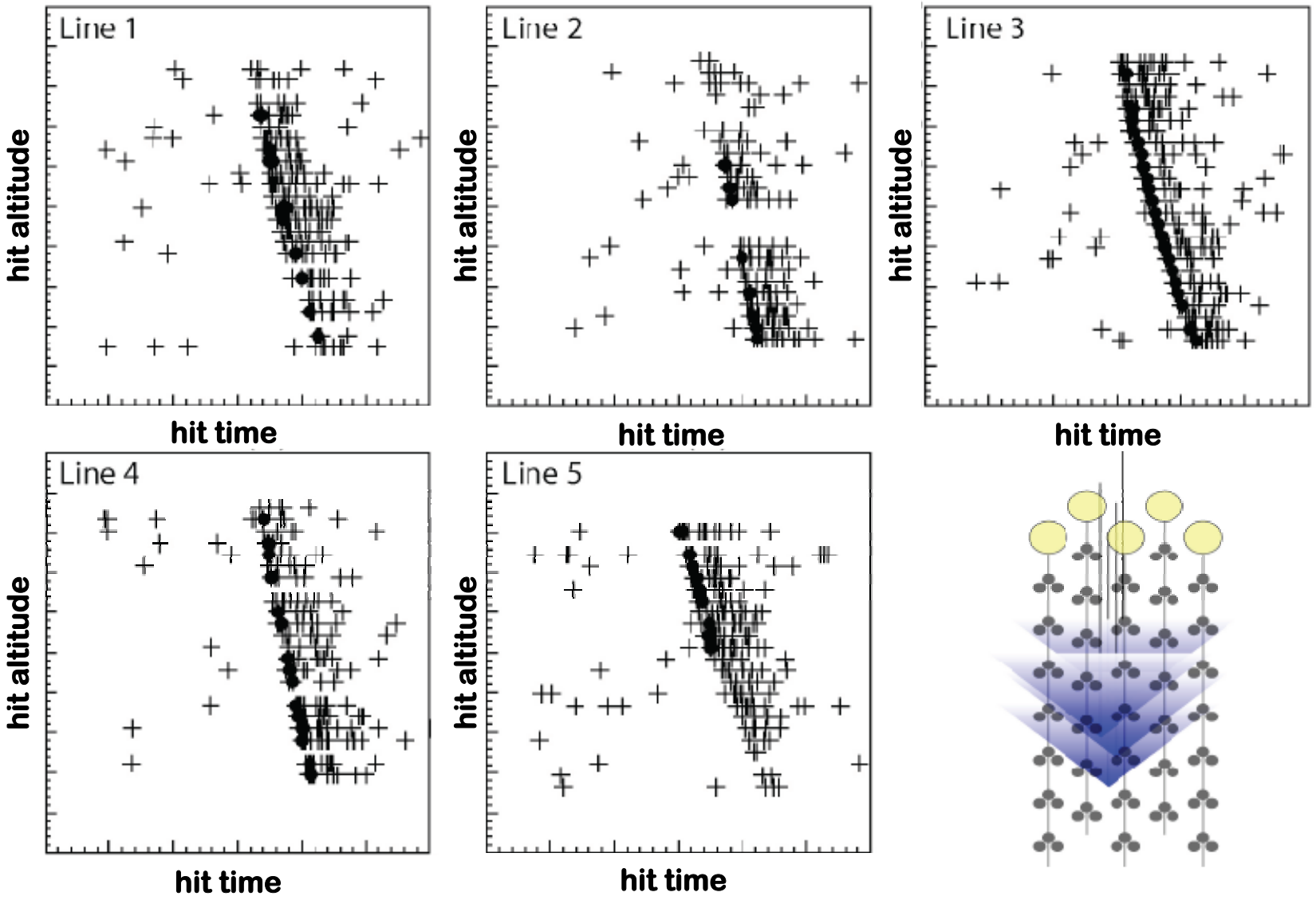


Muon Event in the Optical Detector

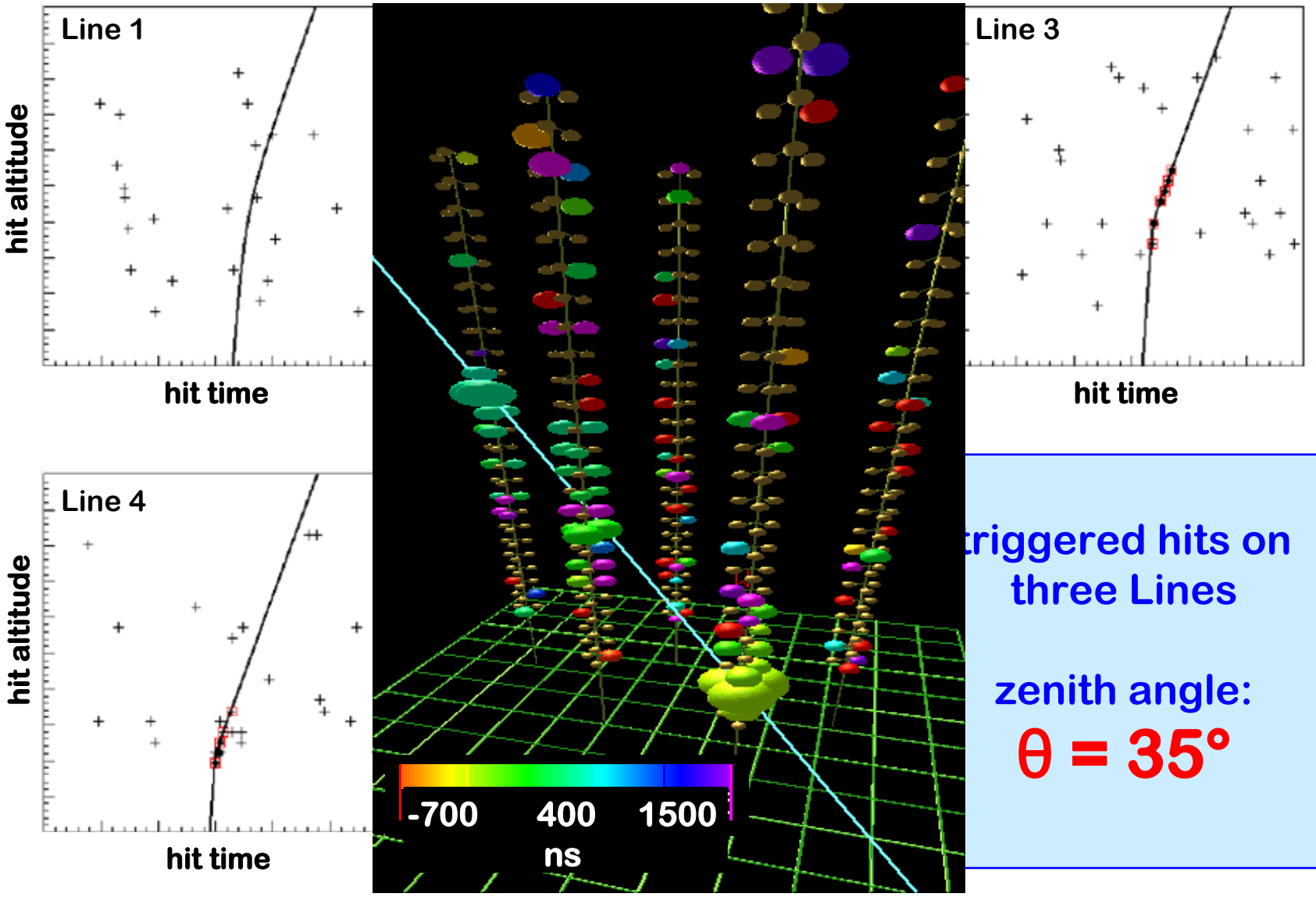


hit pattern depending on zenith angle and distance from string

Selected Events: Muon Bundle



Selected Events: Neutrino Candidate



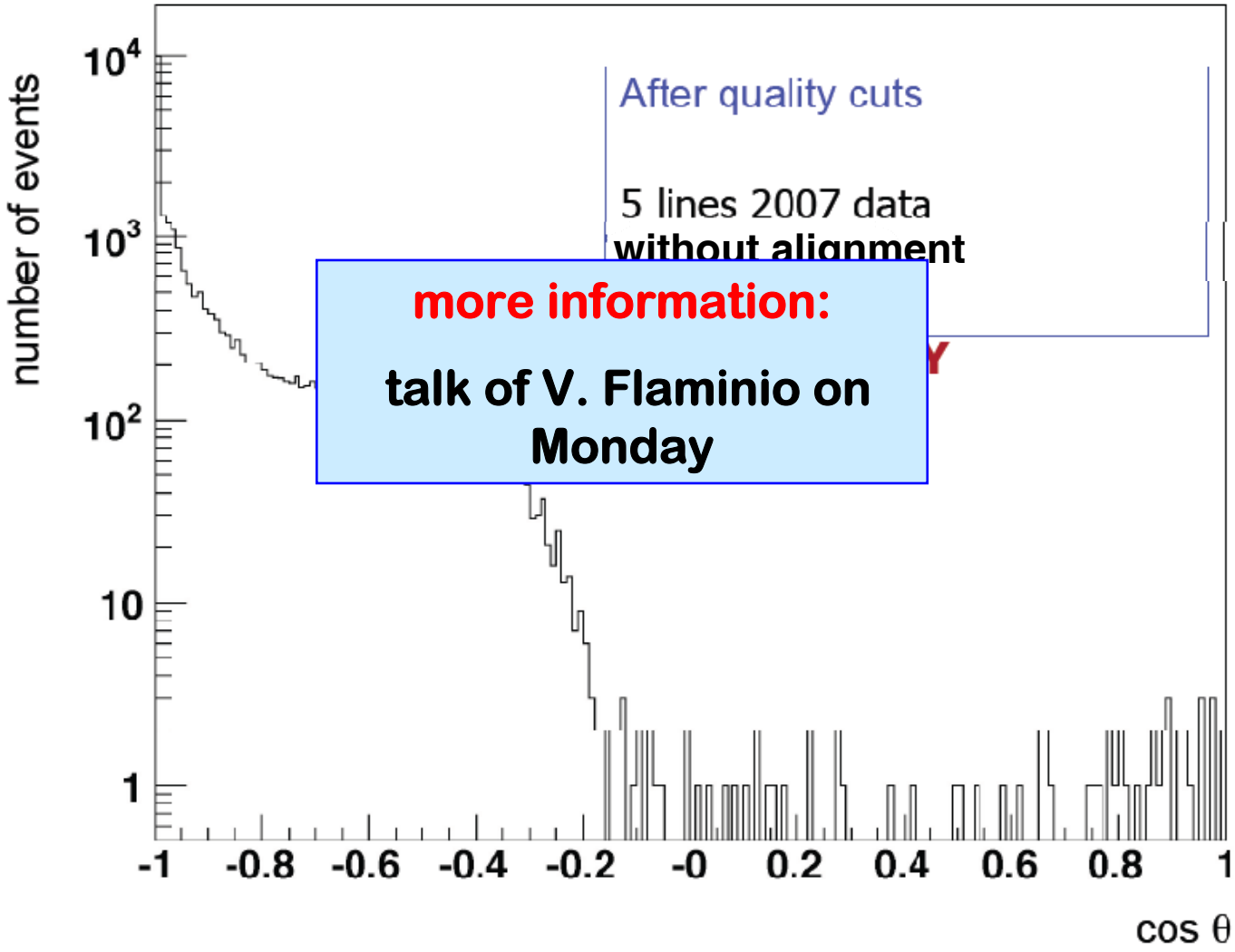
triggered hits on three Lines

zenith angle:

$\theta = 35°$

Nadir Angle Distribution

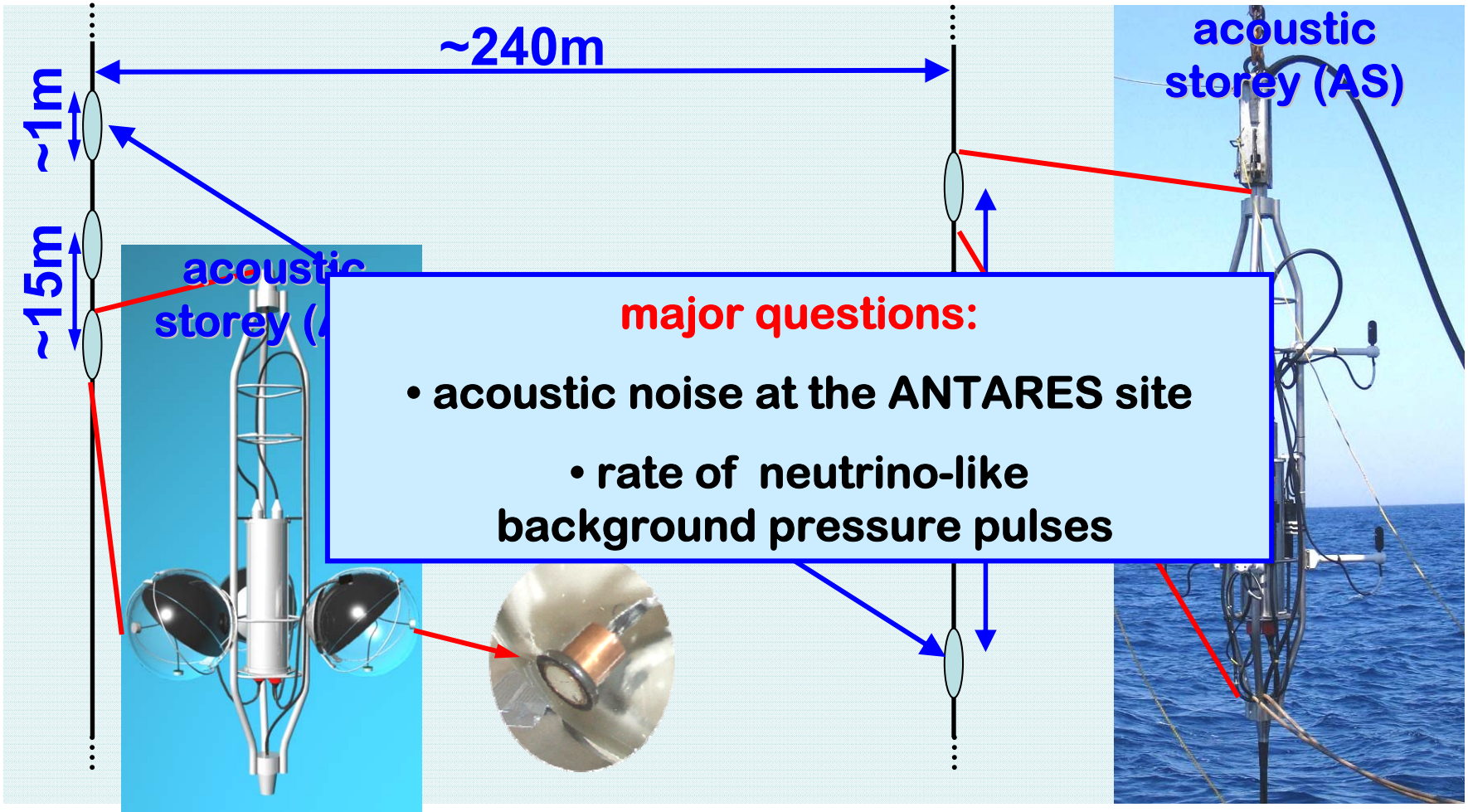
⇓ from above from below +



more information:

talk of V. Flaminio on Monday

The Acoustic Setup

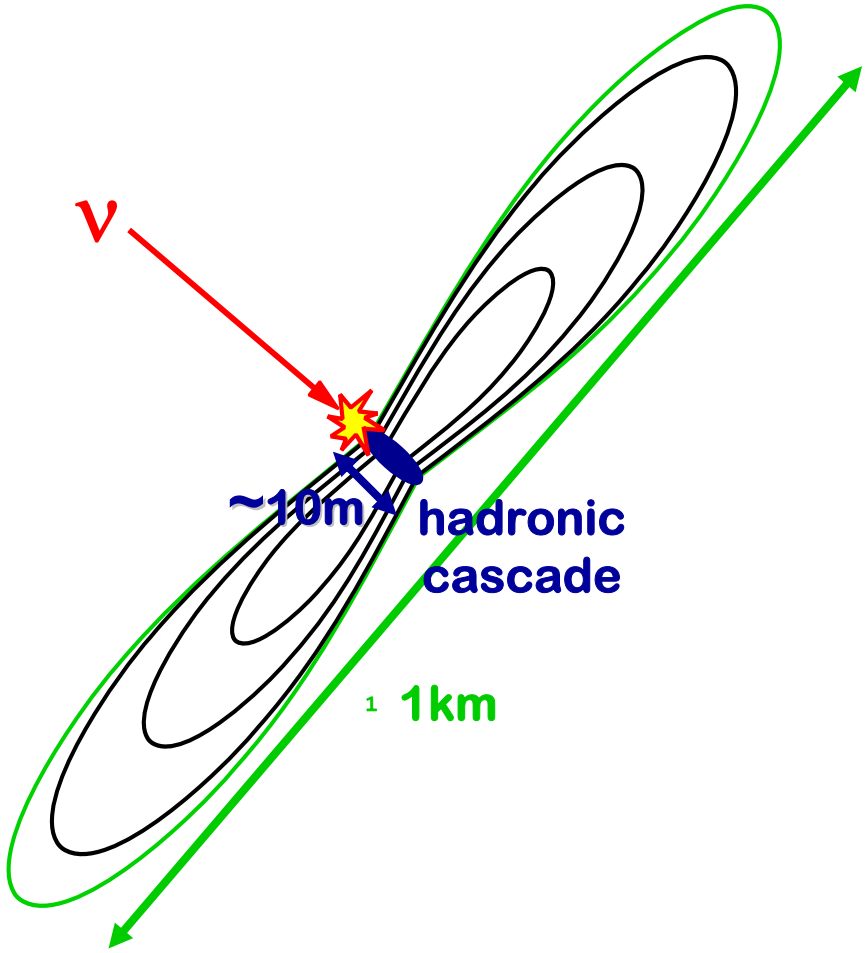


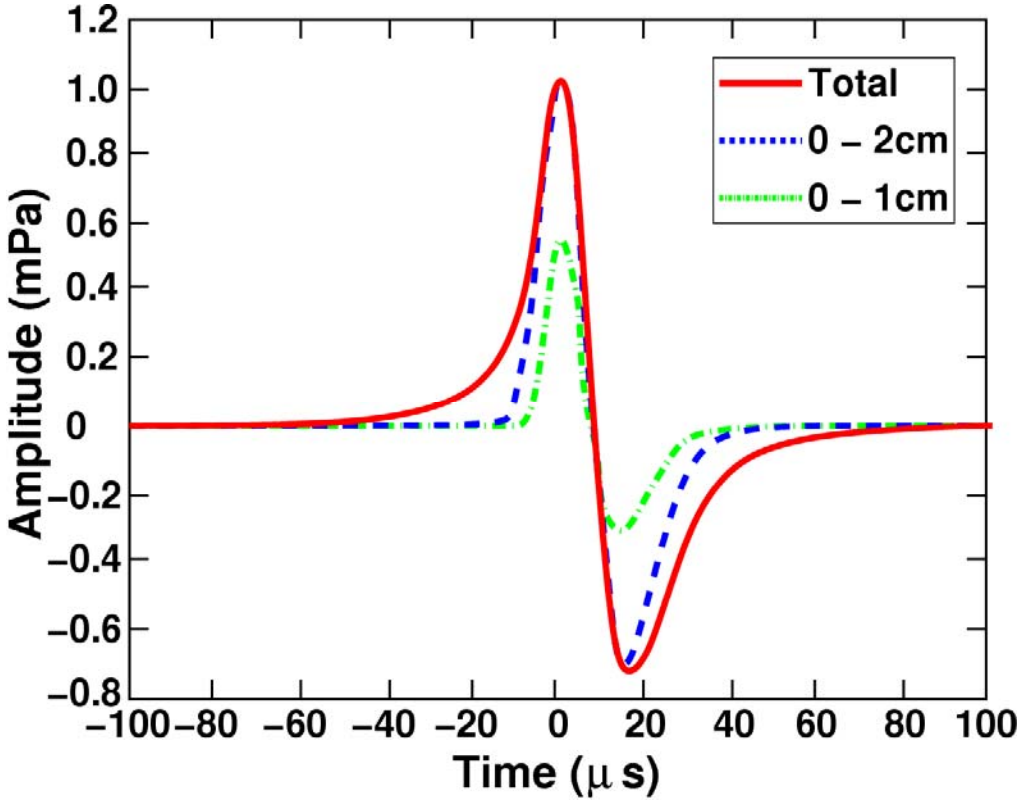
6 storeys with 6 sensors each at different length scales (1 m – 350 m)

The Acoustic Signal of UHE Neutrinos

energy deposition in (hadronic) cascade

*** bipolar pressure pulse in disc shape**

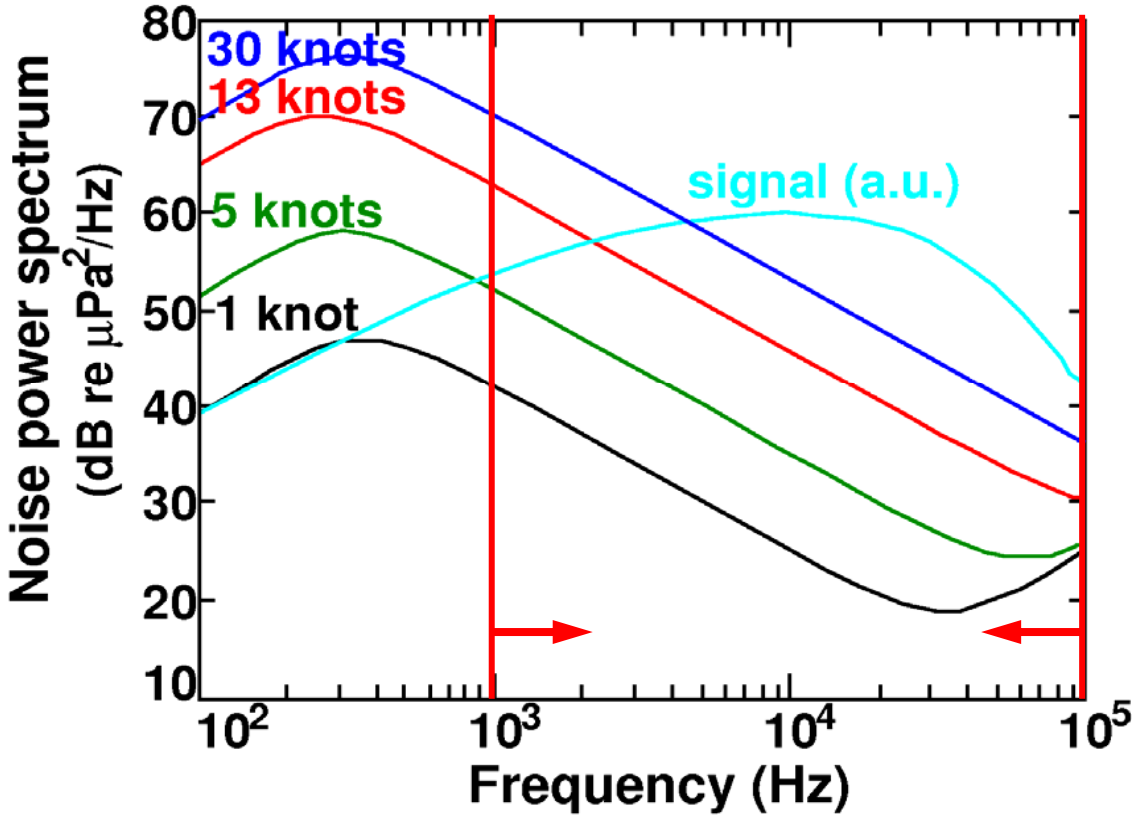




S. Bevan et al., arXiv:0704.1025

$$P(r = 1\,\mathrm{km}) \approx 2 \times \frac{E_{casc}}{1\,\mathrm{EeV}}\,\mathrm{mPa}$$

Noise in the Deep Sea



N.G. Lehtinen et al., Astropart. Phys., 17(2002), p. 279

background noise at low wind speed:

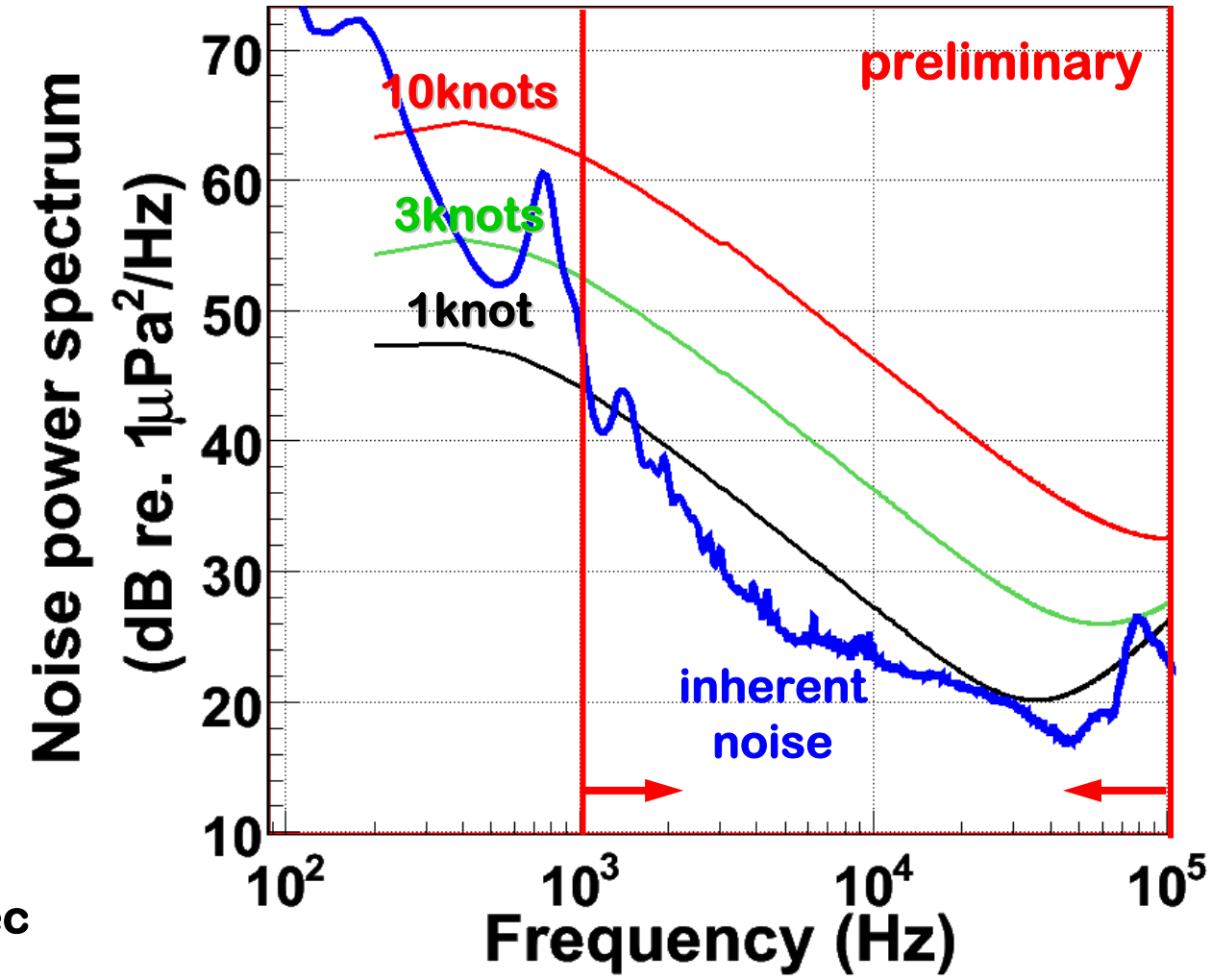
- **3 mPa (rms, 1 – 100 kHz)**

–

P_ν (1EeV@1000m)

DAQ Characteristics

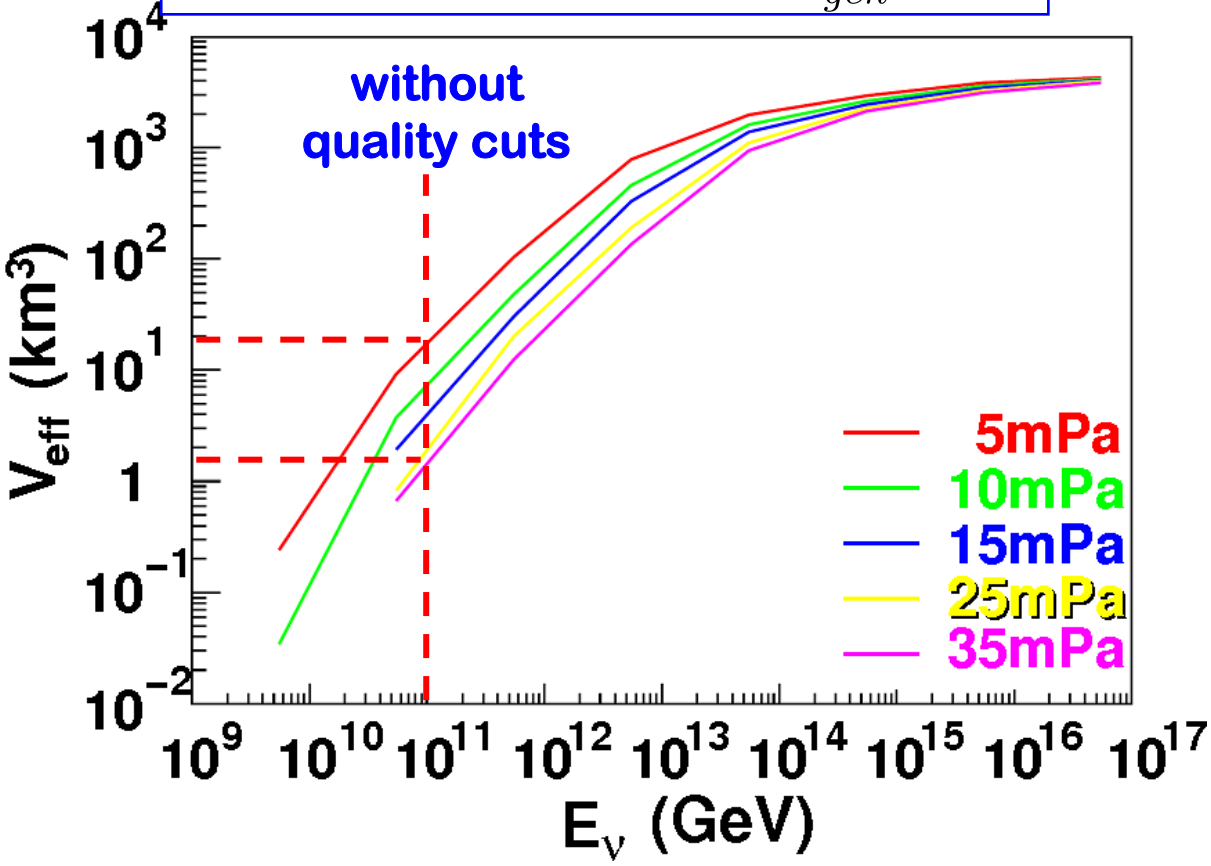
- **typical sensitivity:**
  ¹ 0.2 V/Pa
- **variable post amplification:**
  gain factor ¹ 1 – 500
- **digitization:**
  in the sea at 16bit with
  125 – 500 kSamples/sec



inherent noise comparable to lowest sea state

Simulations of an Acoustic Detector

$$V_{inst} = 1\,\mathrm{km}^3;\ V_{eff} = \frac{N_{det}}{N_{gen}} \cdot V_{gen}$$

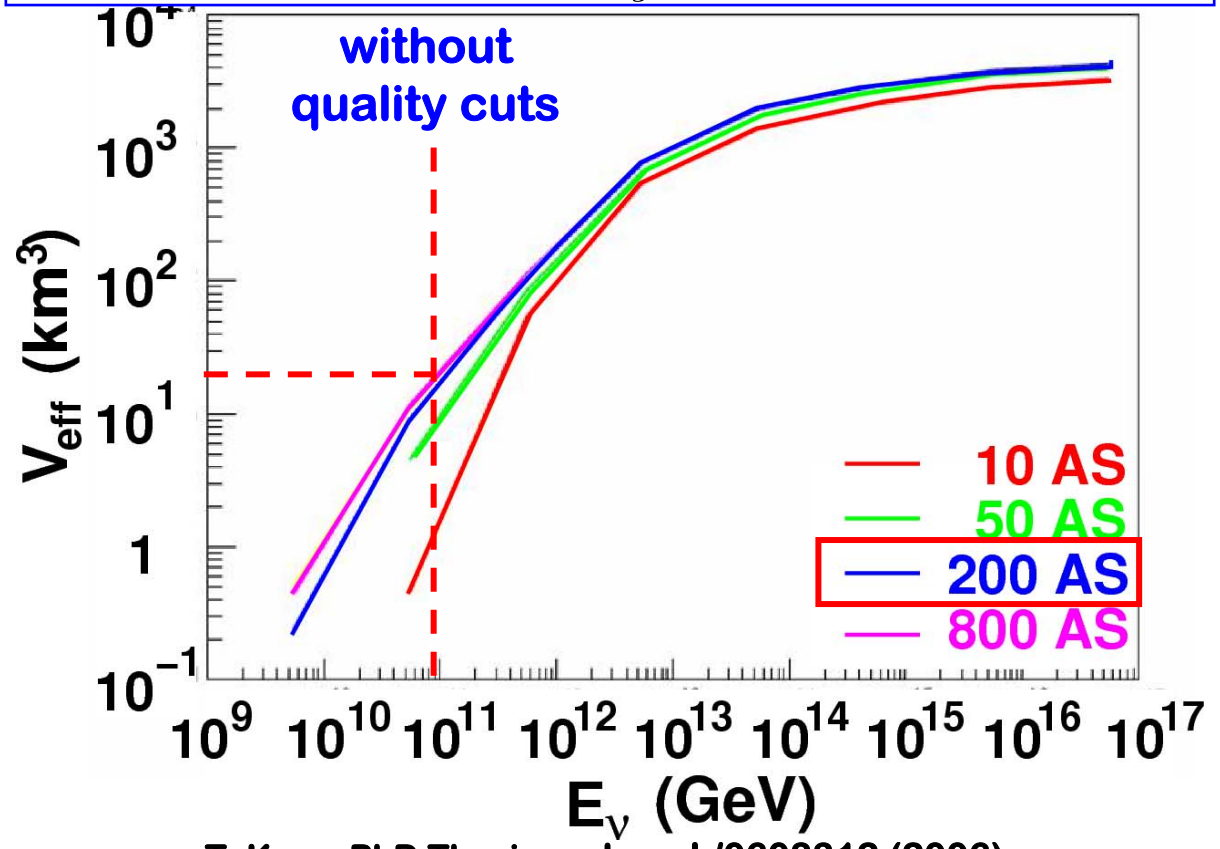


T. Karg, PhD Thesis, astro-ph/0608312 (2006)

strongly dependent on detection threshold of sensors
* design and test efficient signal processing algorithms

Simulations of an Acoustic Detector

$$V_{inst} = 1\,\mathrm{km}^3;\ V_{eff} = \frac{N_{det}}{N_{gen}} \cdot V_{gen};\ P_{th} = 5\,\mathrm{mPa}$$



T. Karg, PhD Thesis, astro-ph/0608312 (2006)

GZK ν event rate: 0.01 – 0.1 per km³ yr

* **detector size > 100 km³ (not with optical detector)**

Summary and Outlook

- Astroparticle physics with neutrinos is important and complementary to the study of other cosmic particles

- The ANTARES neutrino telescope is approaching its completion

- 5 lines are working well and delivering a lot of physics data
  * first neutrino candidates

- Analysis of the data is in progress, understanding of the detector has to be improved

- Feasibility test for a future acoustic detector will start this year with an dedicated array of sensors