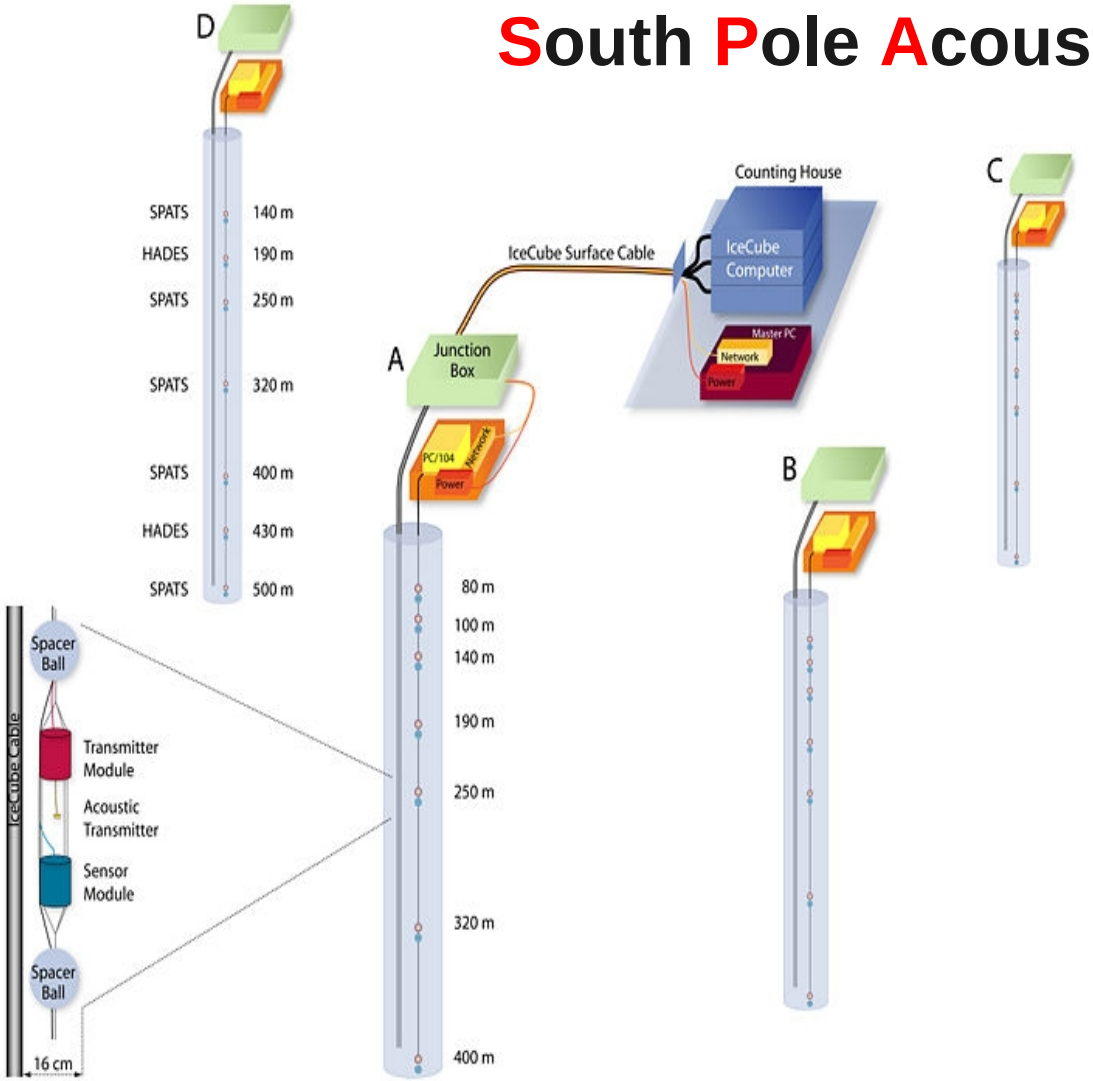
Results, status and perspectives of the work on acoustic detection of neutrinos at the south pole

Jens Berdermann, DESY

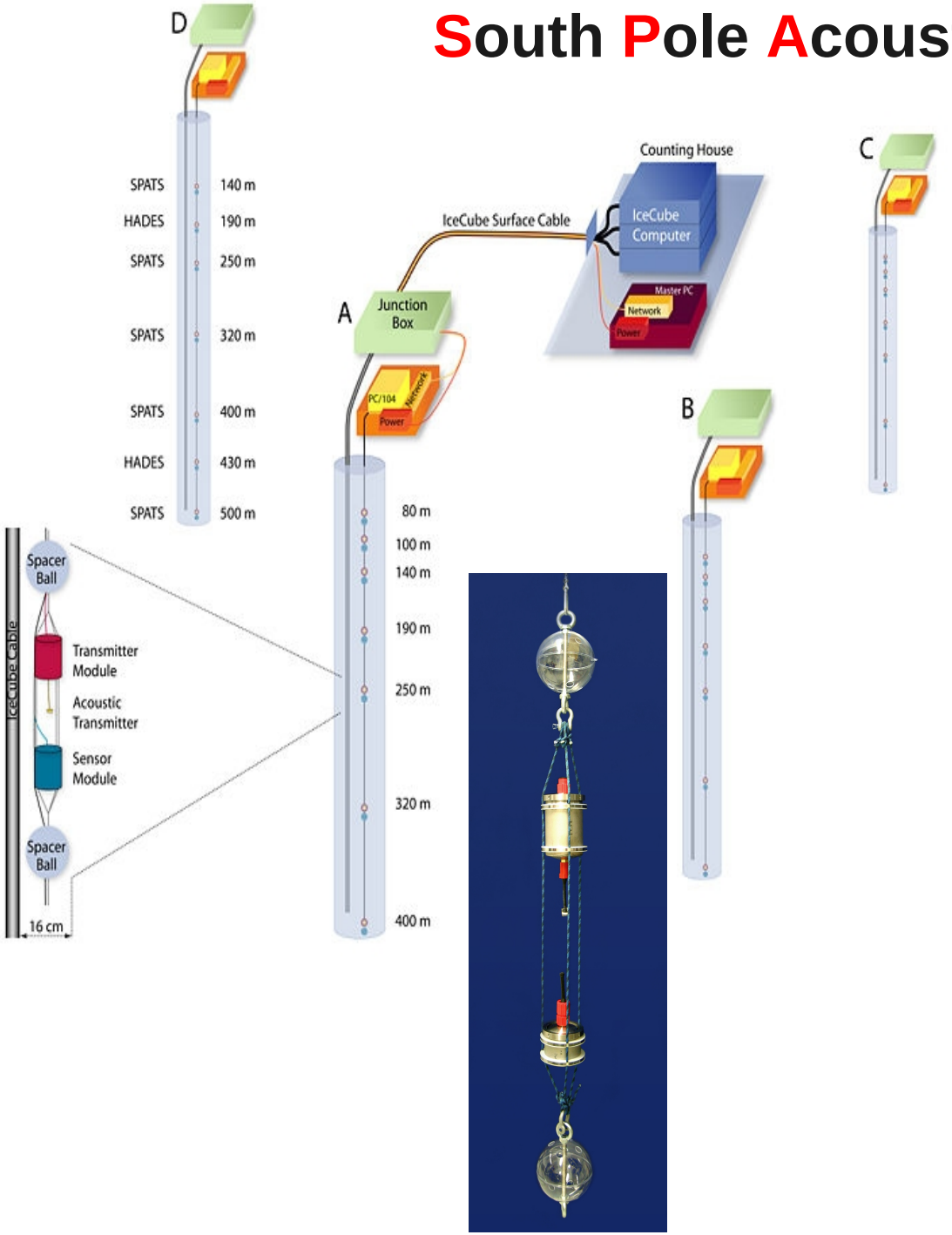
13th ICATPP, Como

October 3rd, 2011

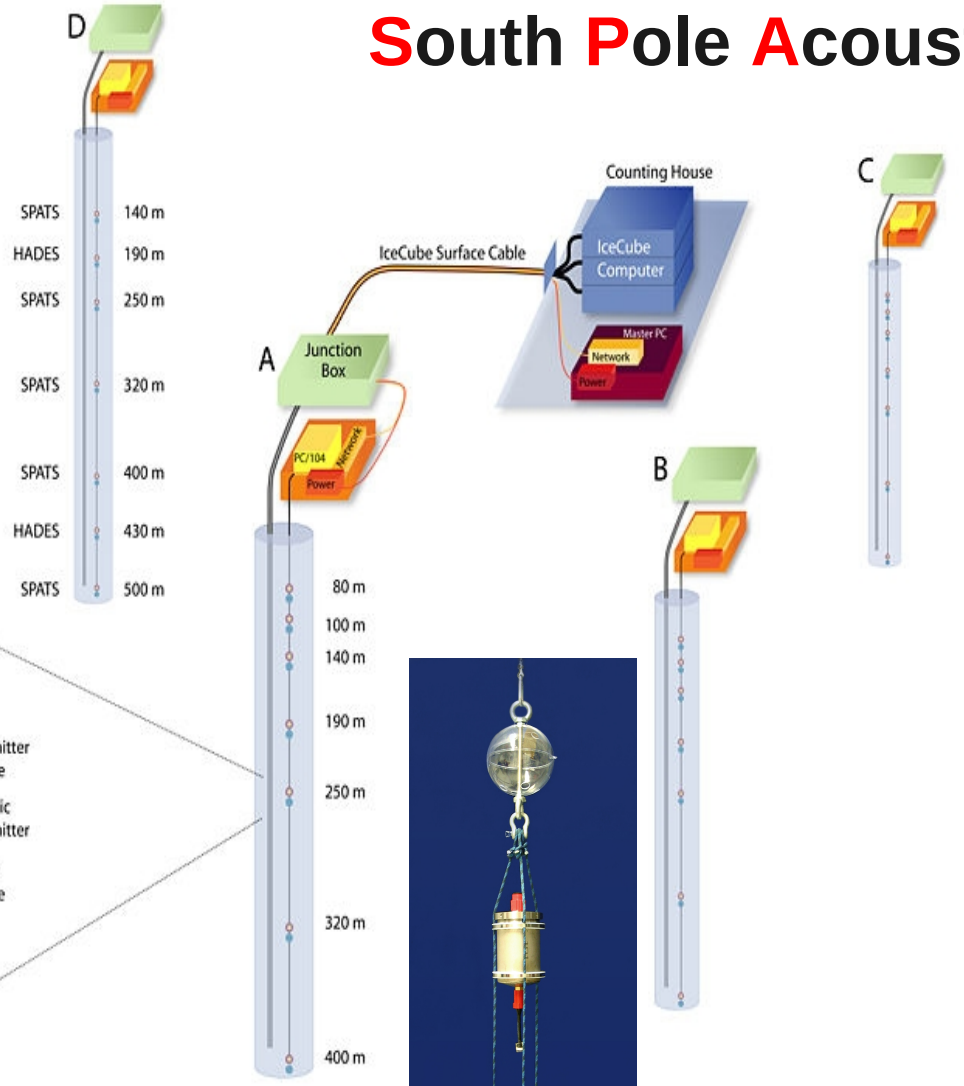
South Pole Acoustic Test Setup

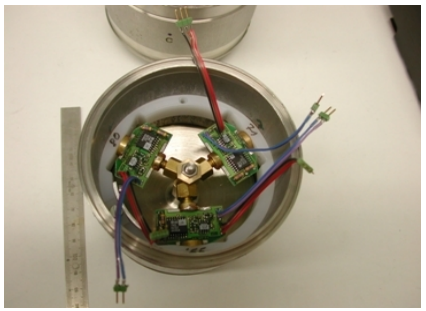


South Pole Acoustic Test Setup



South Pole Acoustic Test Setup





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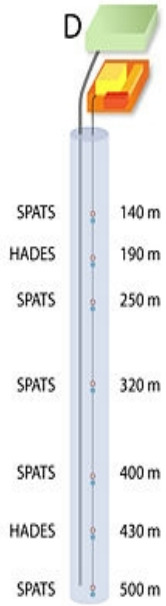

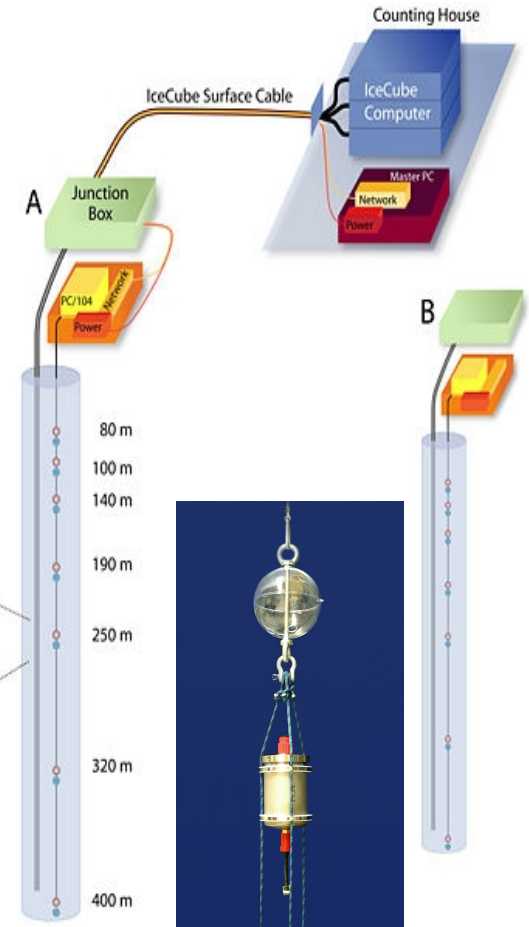

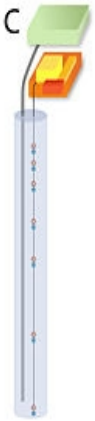

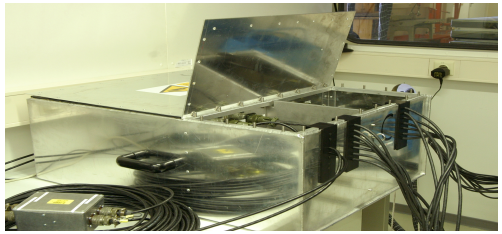

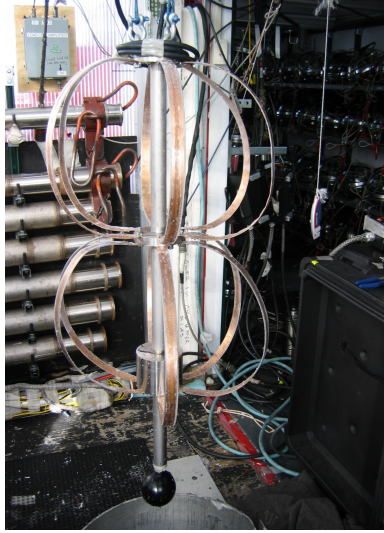

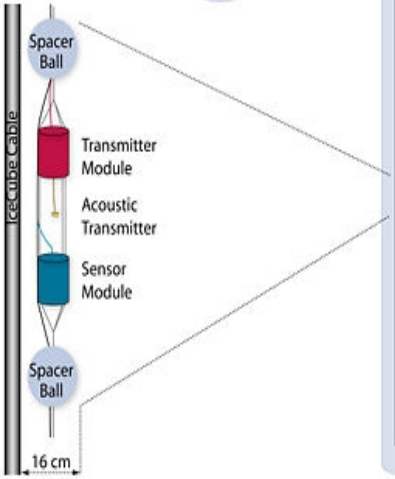

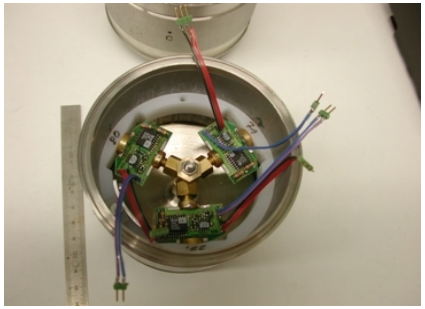

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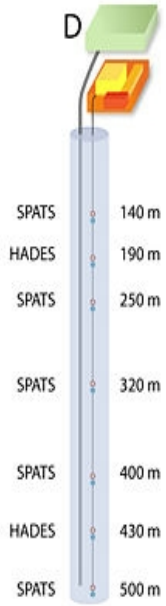
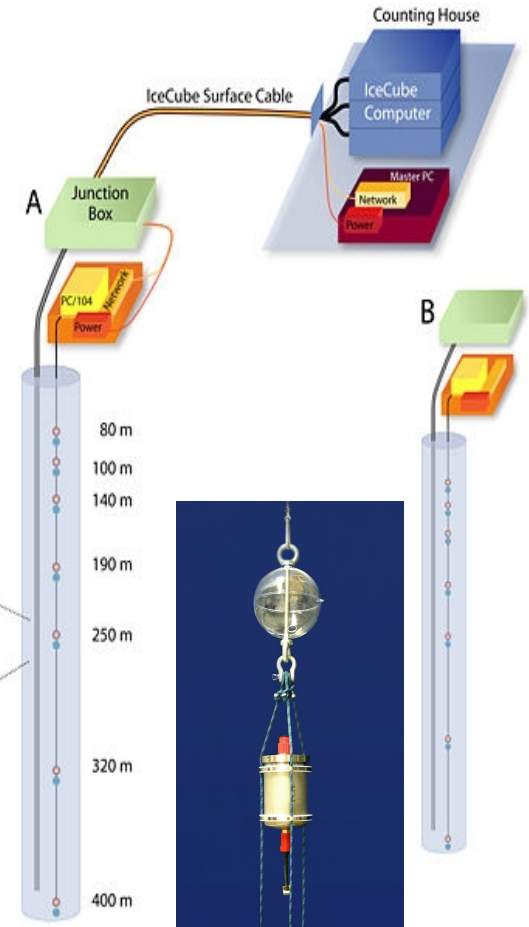
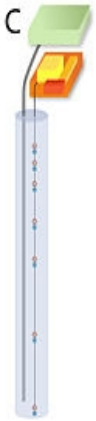
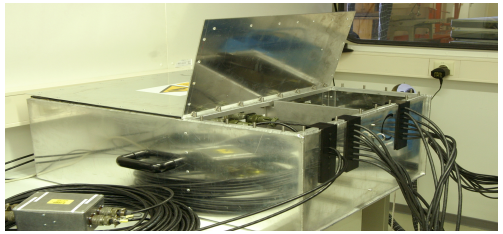
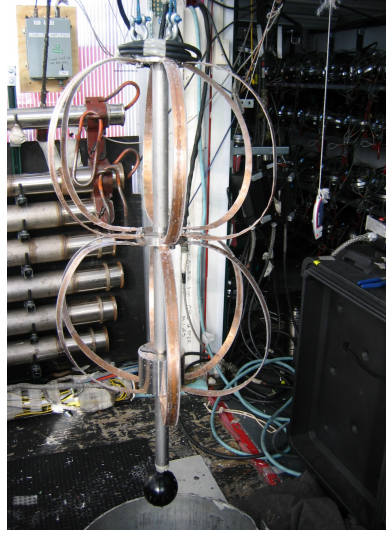
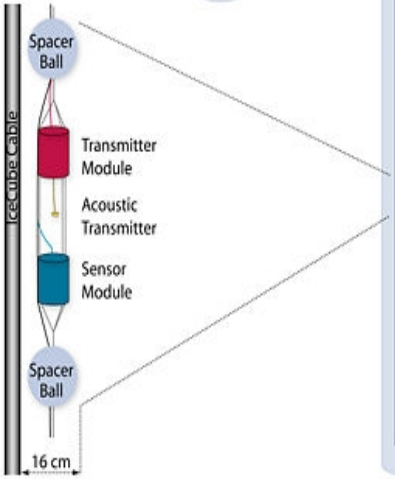


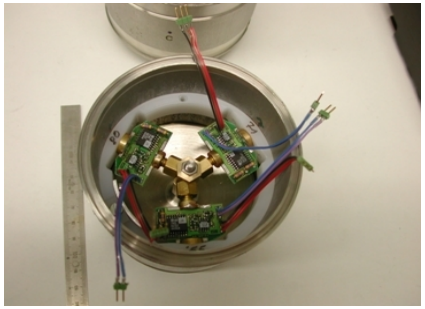






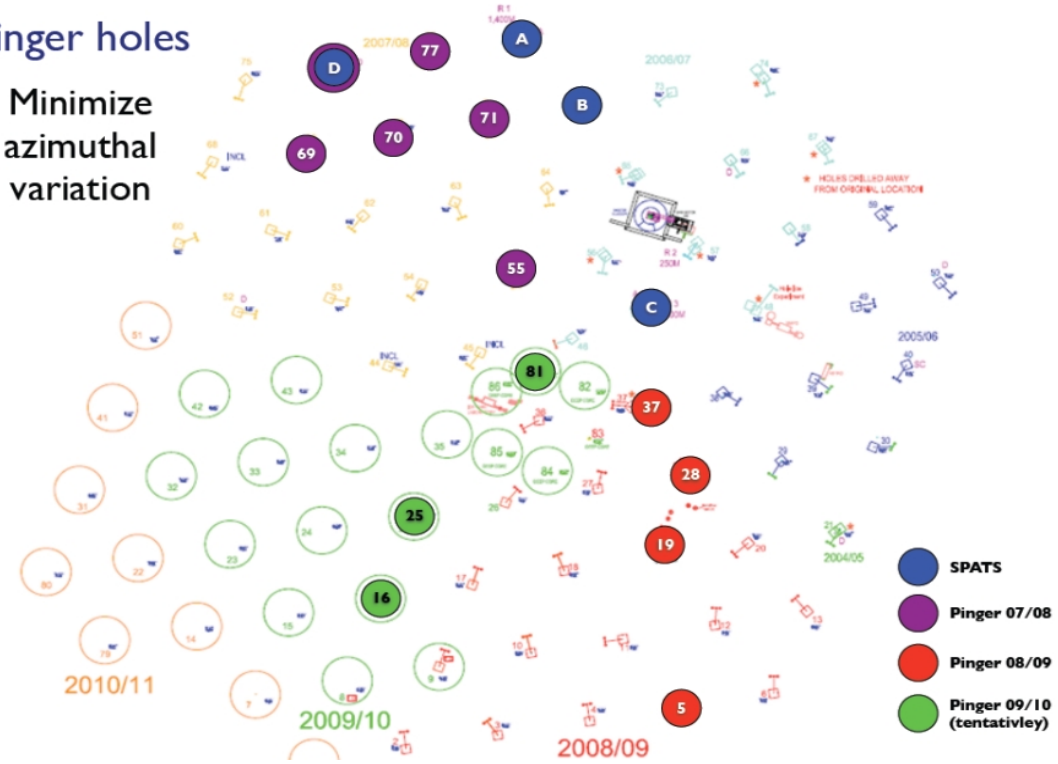




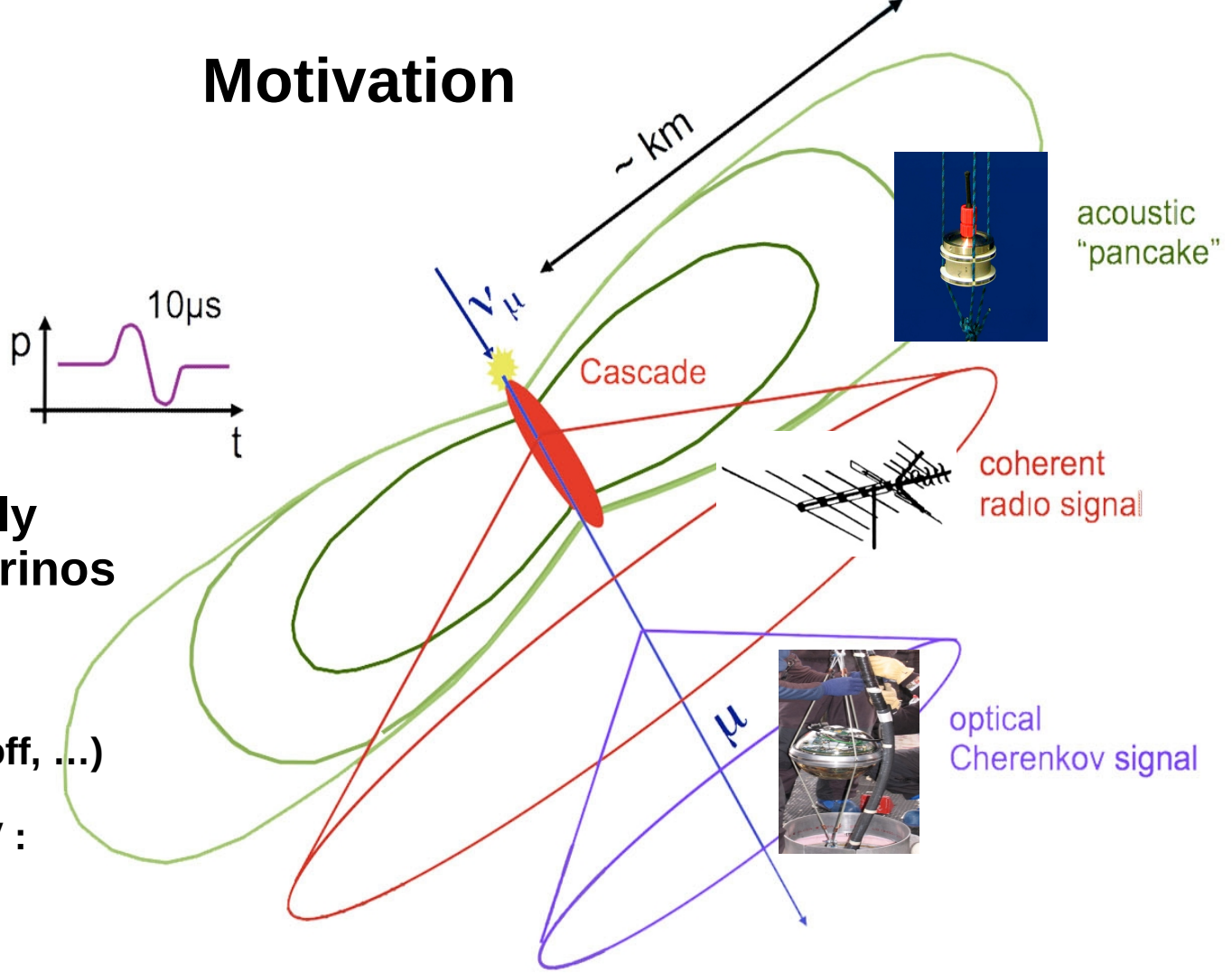


Pinger holes

Minimize azimuthal variation



Motivation



Confirm GZK cutoff !

Do physics with extremely high energy cosmic neutrinos

- **Astrophysics - E > 10^16eV : study origin of cosmic rays (AGN's, black holes, GZK cutoff, …)**
- **particle physics - E > 10^18eV : study neutrino cross section (sphalerons, mini BH,…)**
- **cosmology - E > 10^21eV : study relic neutrino background radiation (UHE absorption at CBR)**

Needs to build ~100 km³ hybrid detector!

SPATS has been designed to measure the local ice properties, the underlying noise floor and to verify the efficiency of a multi km³ detector!

Scientific goals of SPATS

Sound Speed:
- sound speed value and depth dependence (refraction ?)

Transient events:
- are there transient events
- what are their features (rate,sources?)
- could they be a significant source of background?

Needs time information

Noise:
- what is the noise level
- which ν energy

Attenuation coefficient:
- is it depth dependent?
- is it frequency dependent?

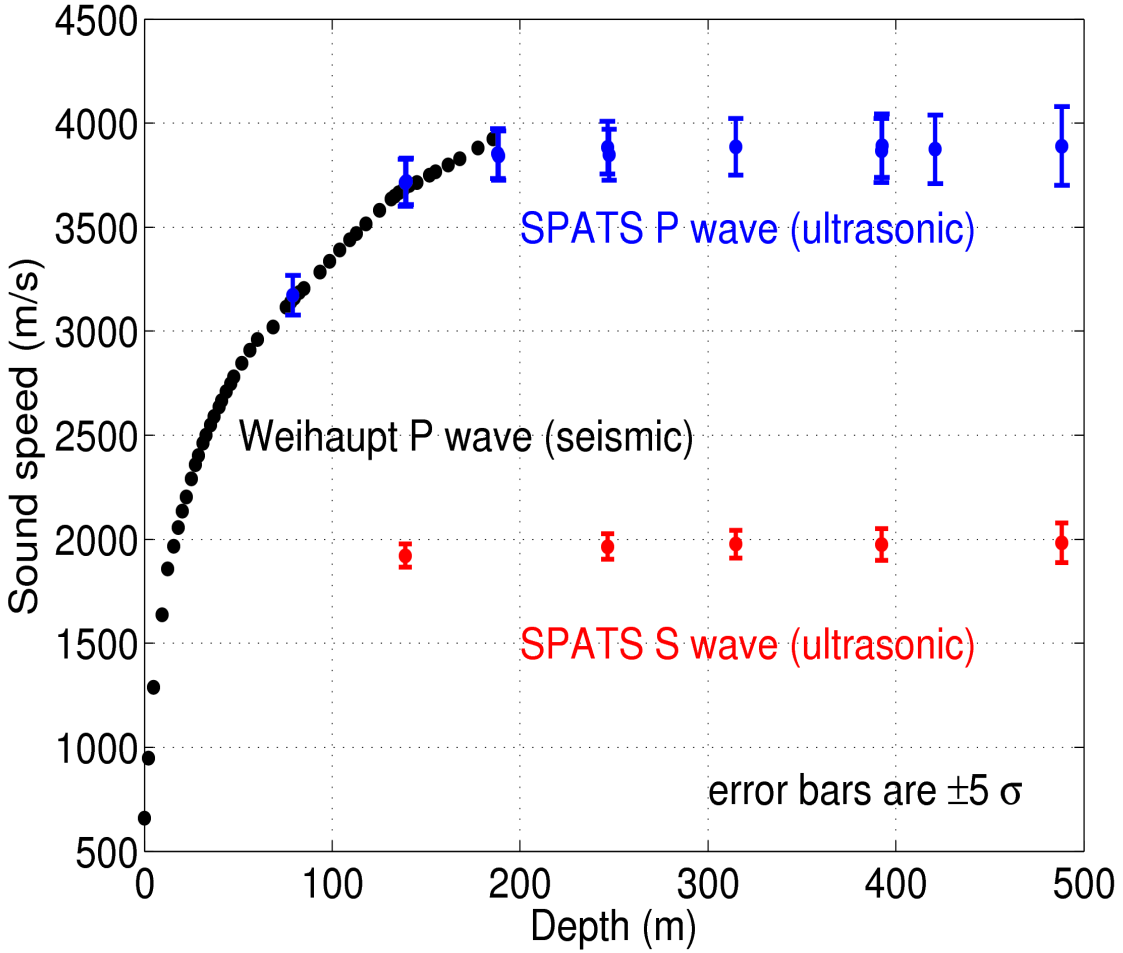
Needs amplitude information

Speed of sound as a function of depth

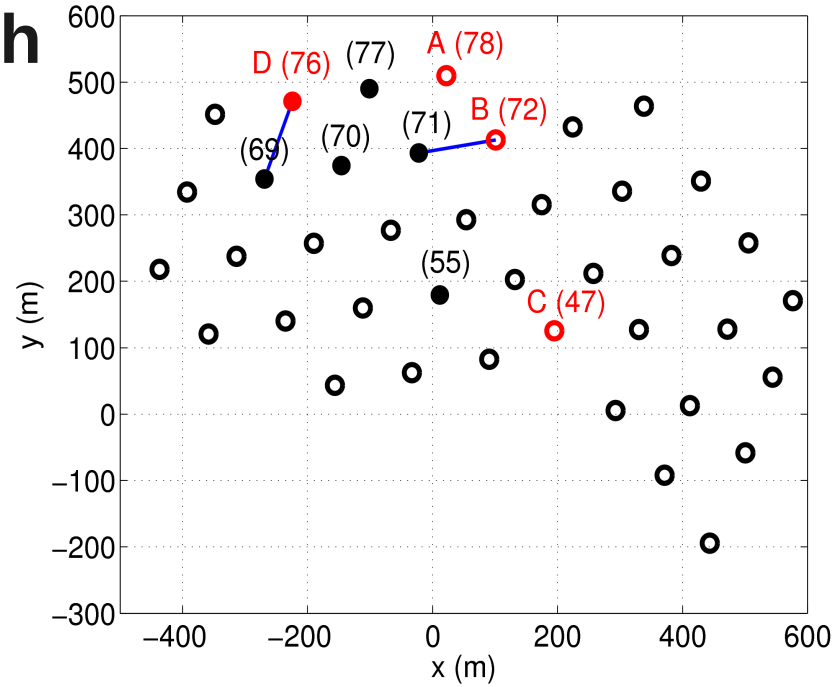
Astropart.Phys.33:277-286 (2010)

$$v_P(375\,m) = (3878 \pm 12)\ \ m/s$$

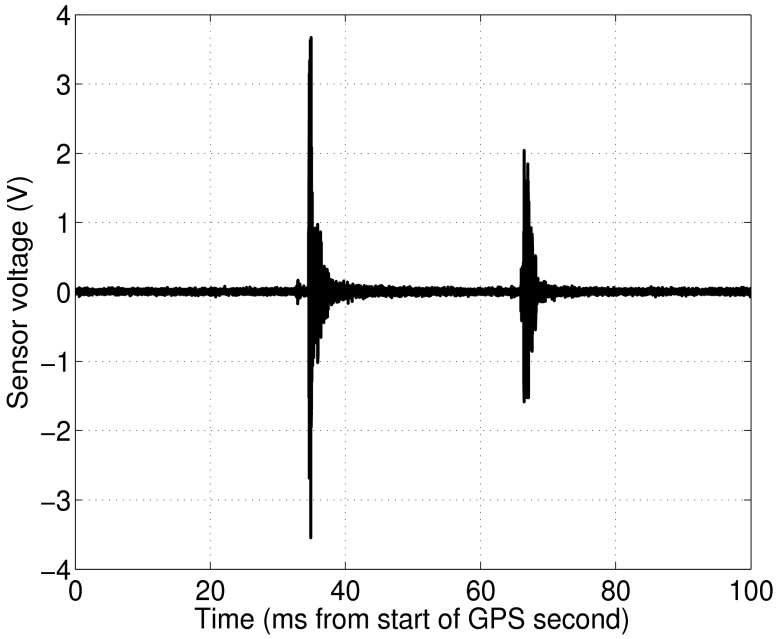
$$v_S(375\,m) = (1976 \pm 8)\ \ m/s$$



*J.G.Weihaupt, Geophysics 28 (4) (1963) 582-592



Hole 69 to DS7−0 (Run 30733, 488.4 m depth) average waveform



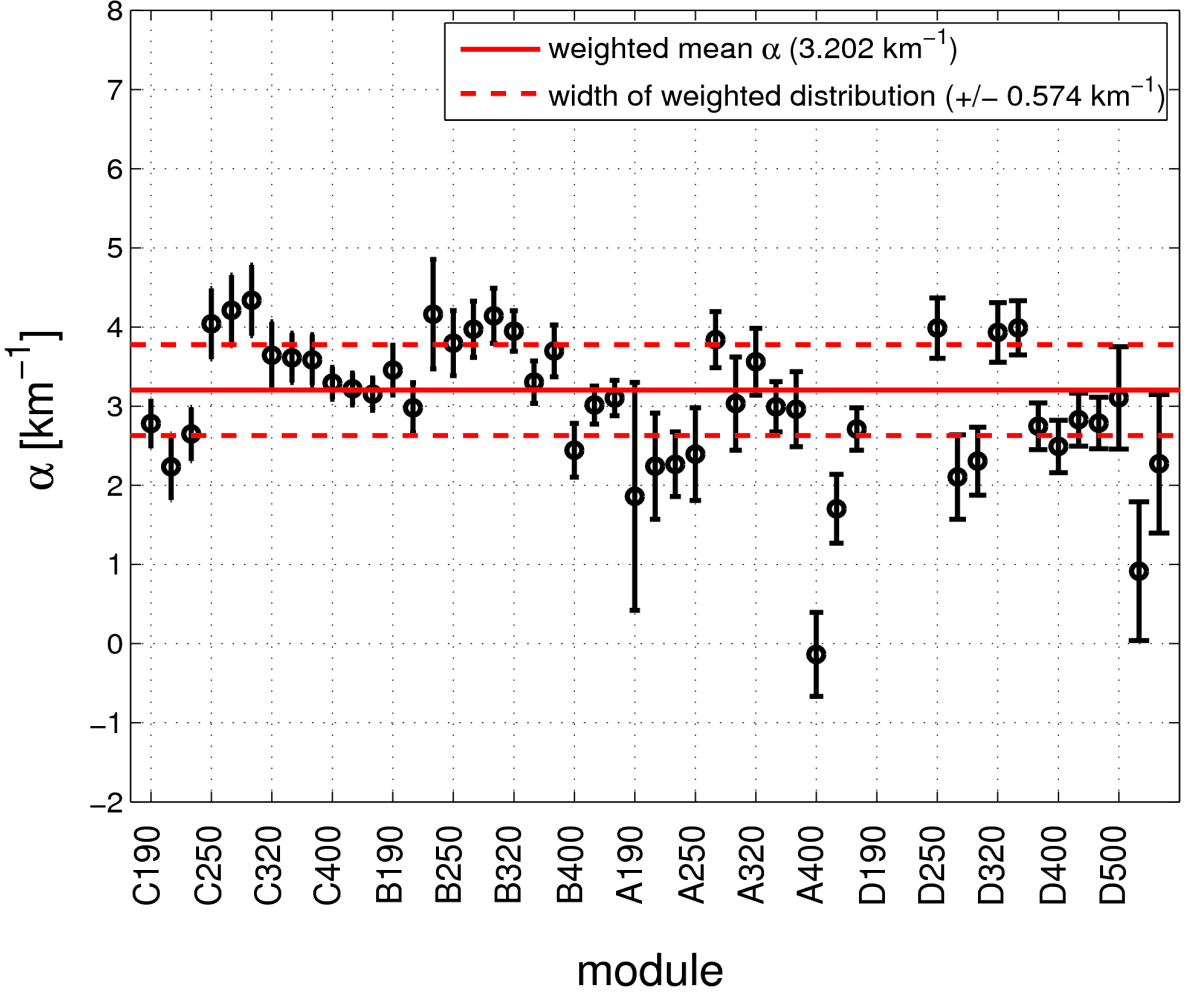
Measurement of acoustic attenuation

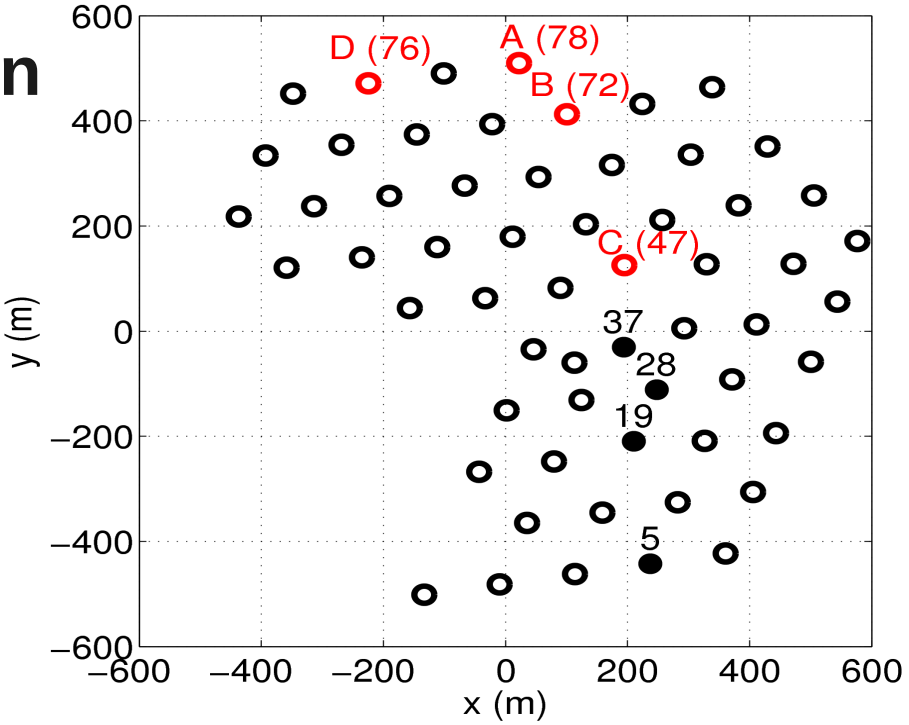
Astropart.Phys.34:382-393 (2011)

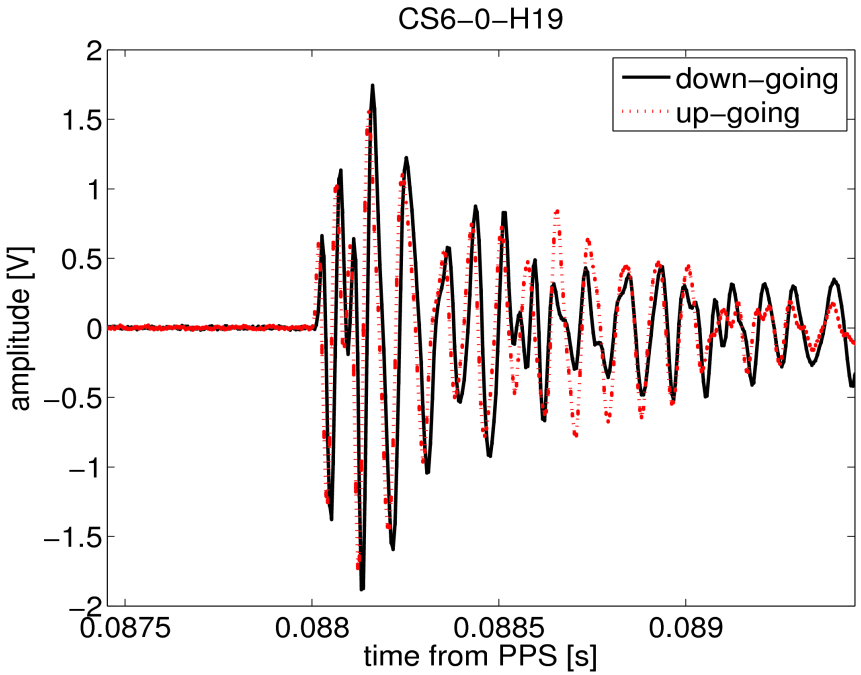
$$A = \frac{A_0}{d} e^{-\alpha d} = \frac{A_0}{d} e^{\frac{-d}{\lambda}}$$

$$<\alpha> = 3.20 \pm 0.57\ km^{-1}$$

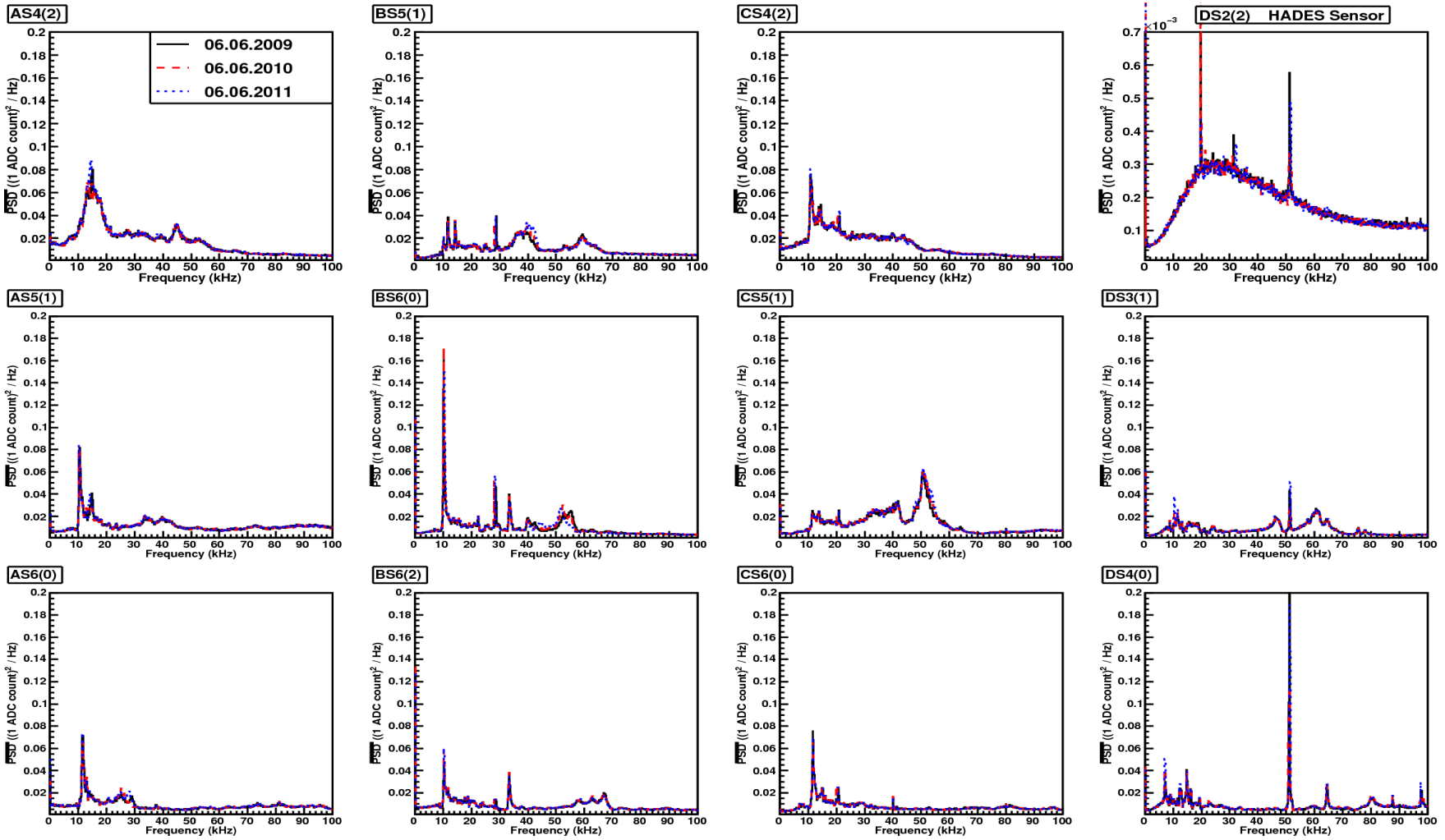
$$<\lambda> = 312^{+68}_{-47} m$$





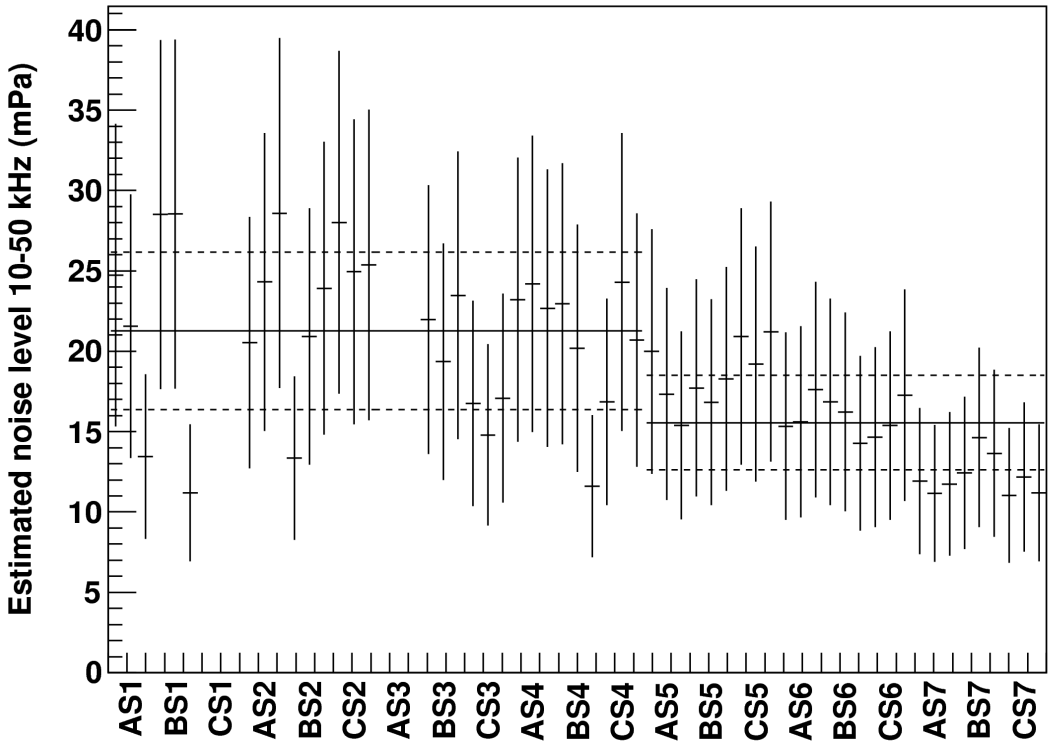


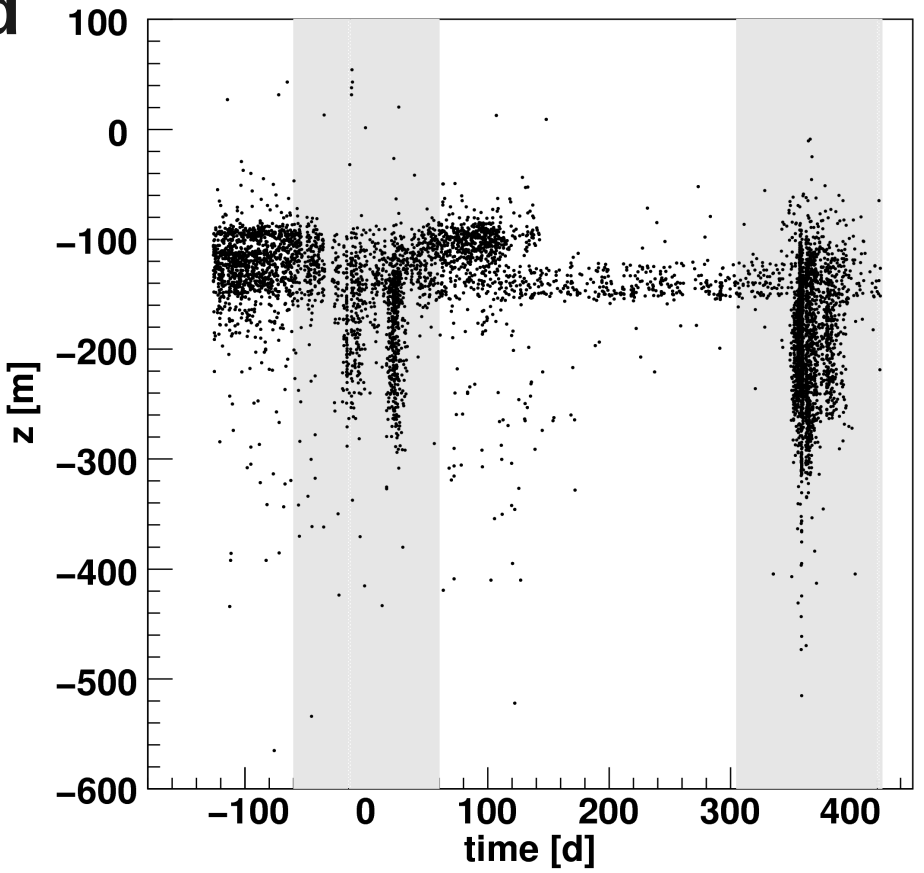
Temporal and spatial background noise distribution



- Stable behavior of the sensor noise during two years
- Frequency spectrum between the single sensors different
  --> individual refreezing and coupling to surrounding ice
- Strength of sensor noise very small compared to a real transient signal

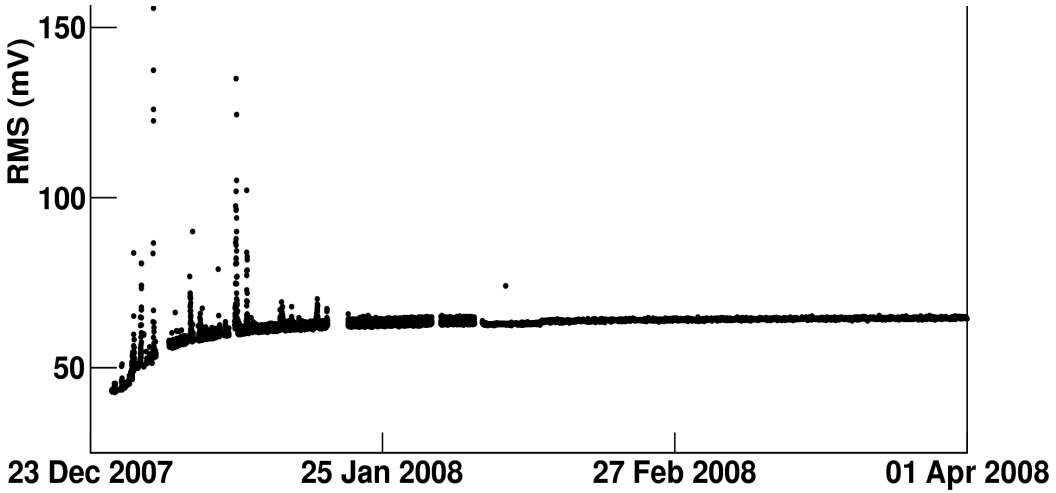
Temporal and spatial background noise distribution





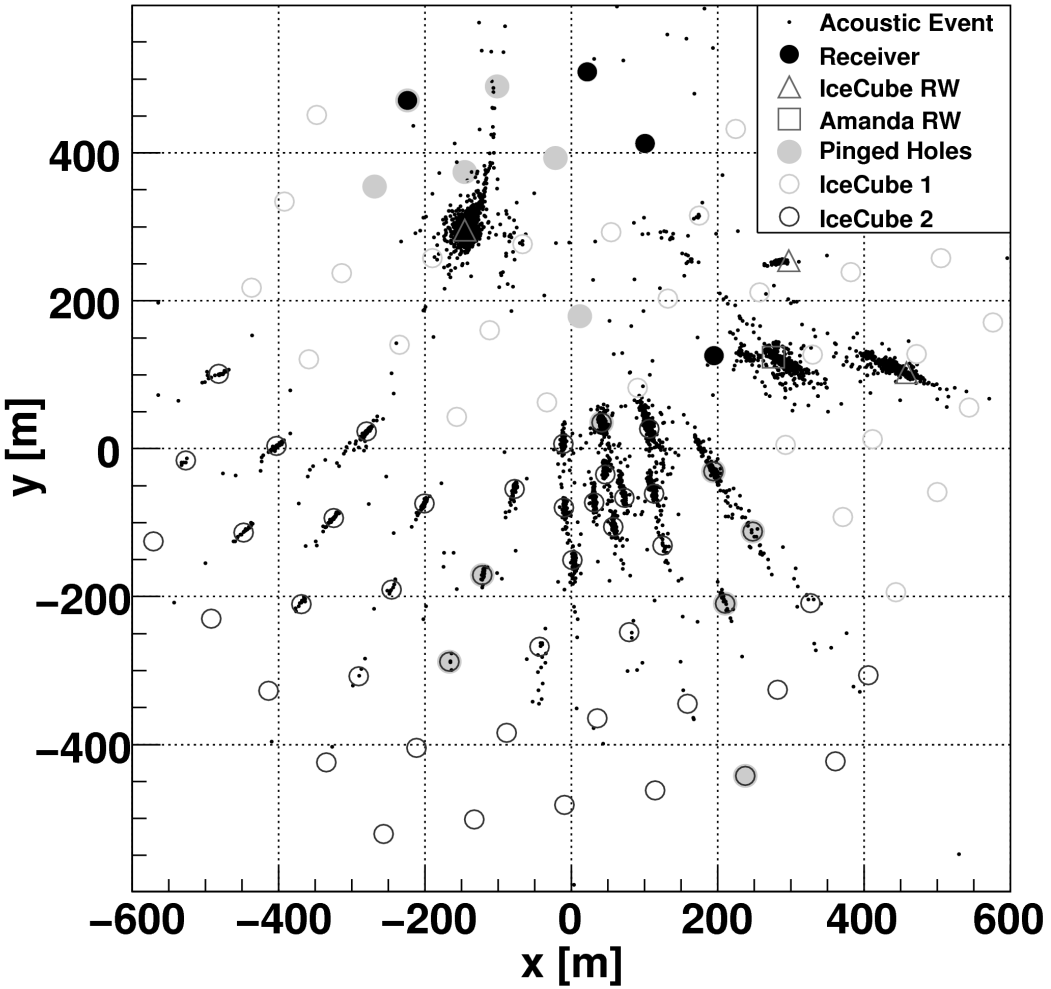
$$P_N(<200\,m) < 14\ \ mPa$$

Corresponds to a neutrino
of energy 10^{11} GeV
interacting at a distance of 1300 m



arXiv:astro-ph/1103.1216 accept. in APP

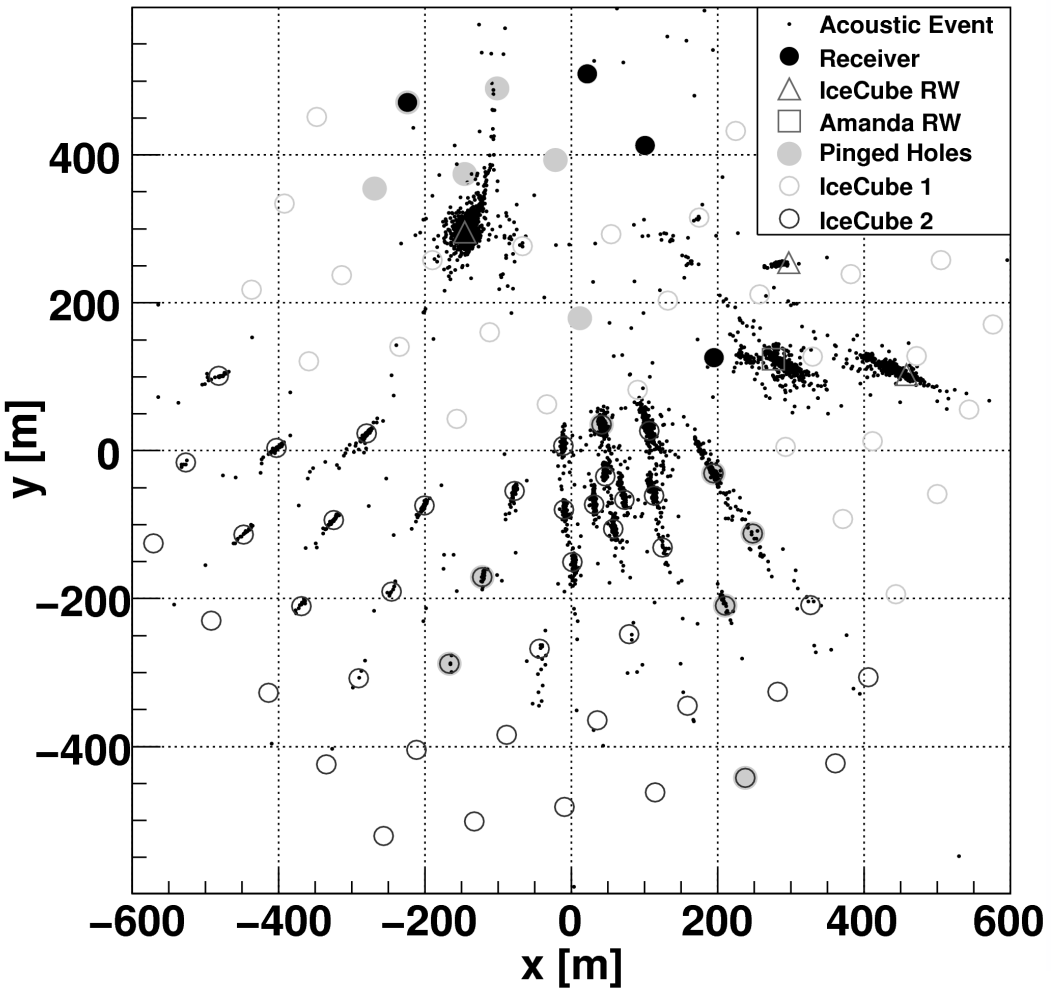
Temporal and spatial background noise distribution

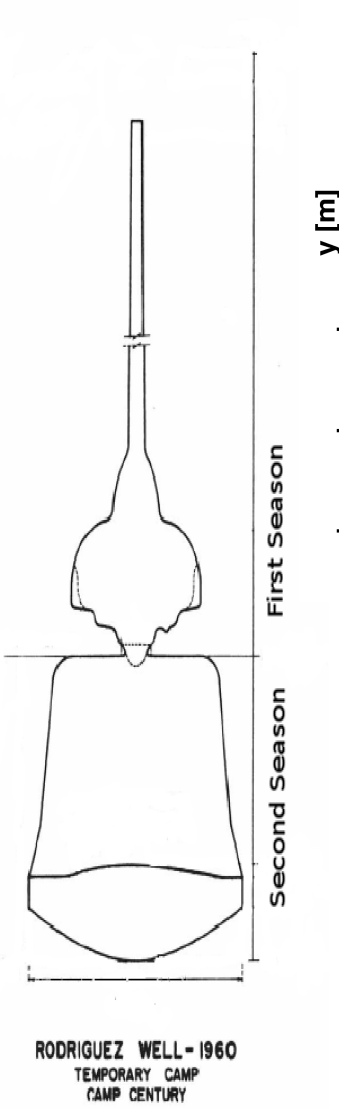


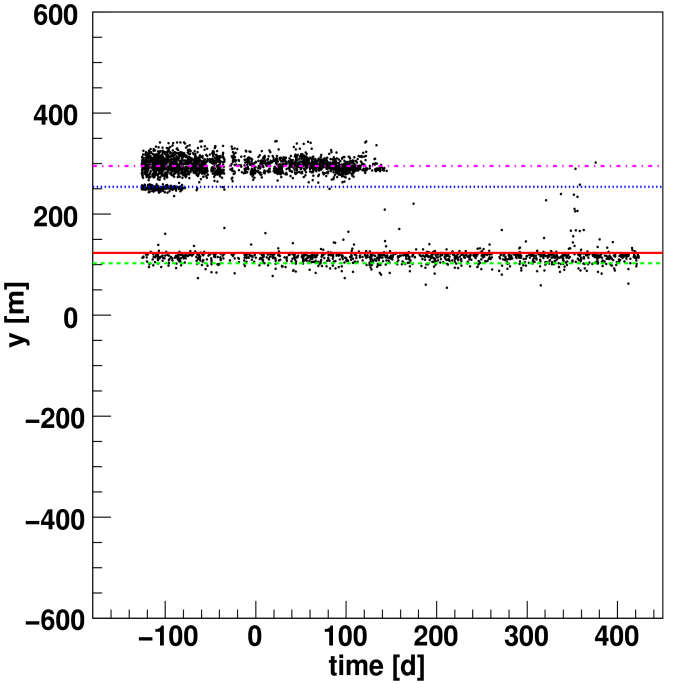
arXiv:astro-ph/1103.1216 accept. in APP

Temporal and spatial background noise distribution

- Rodriguez-Wells -





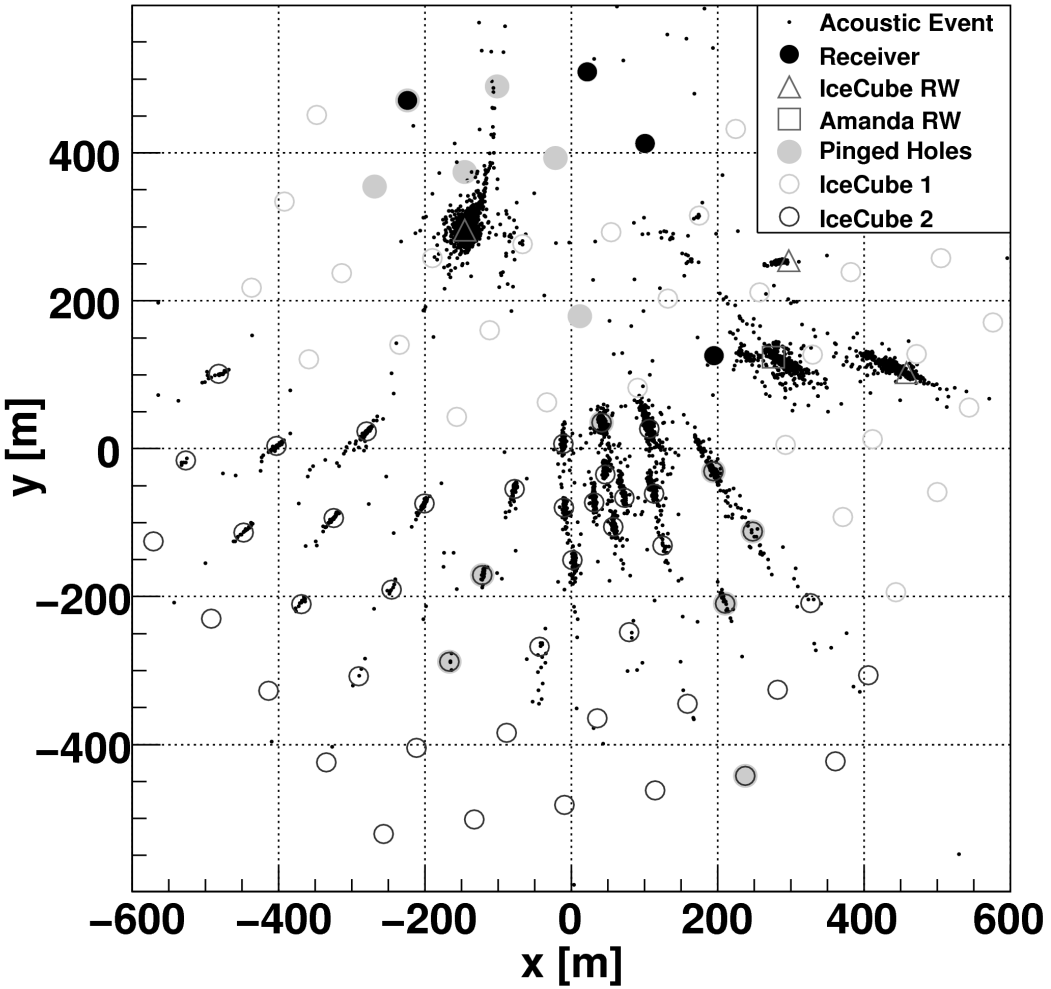


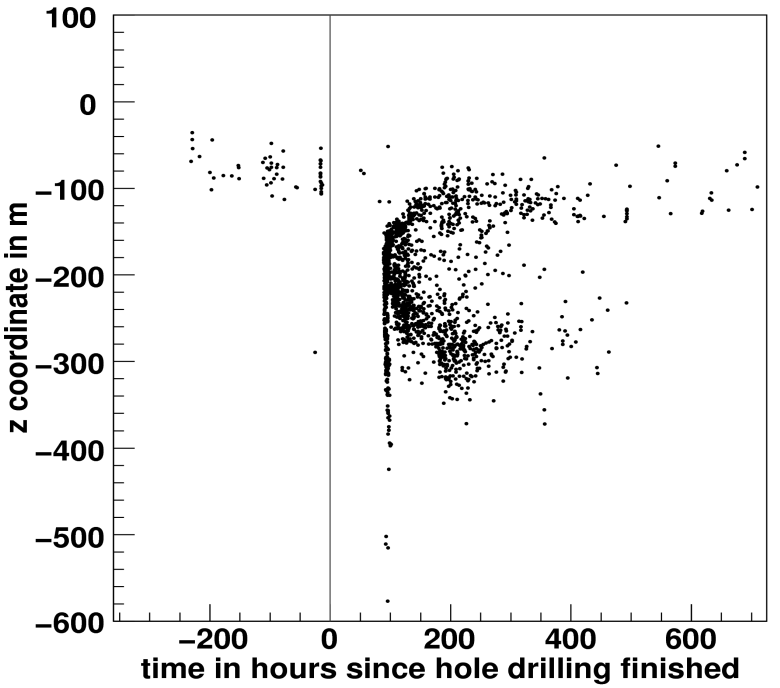
Name	used	seen until
AMANDA RW	2y	now
IC-RW 04-06	2y	now
IC-RW 06/07	1y	Oct. 08
IC-RW 07/08	1y	May 09

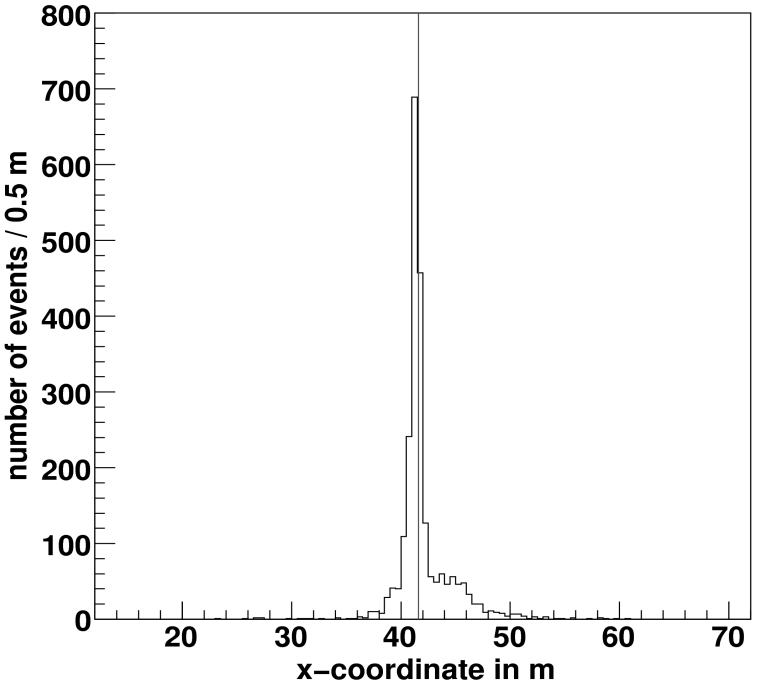
arXiv:astro-ph/1103.1216 accept. in APP

Temporal and spatial background noise distribution

- IceCube holes -







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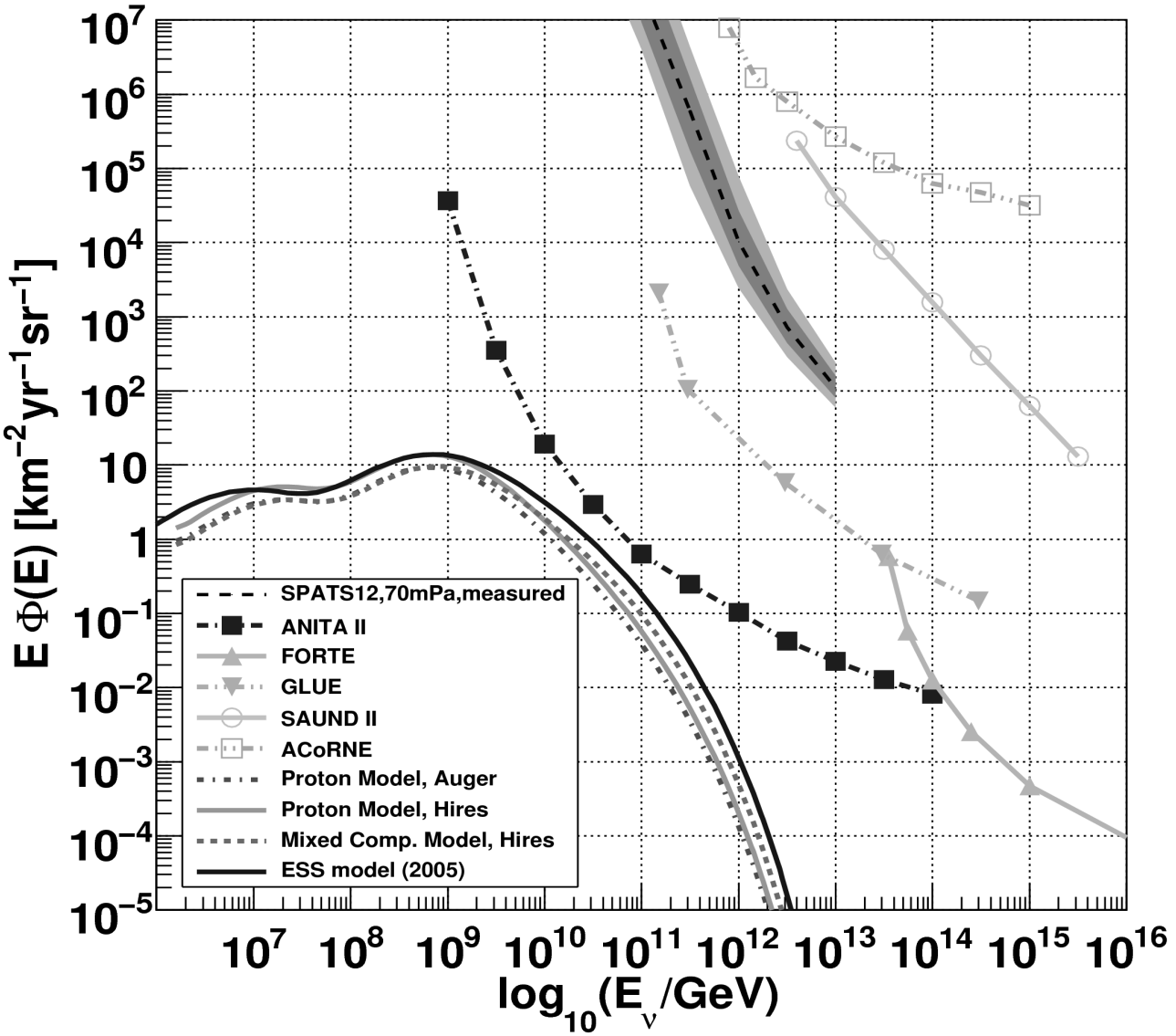
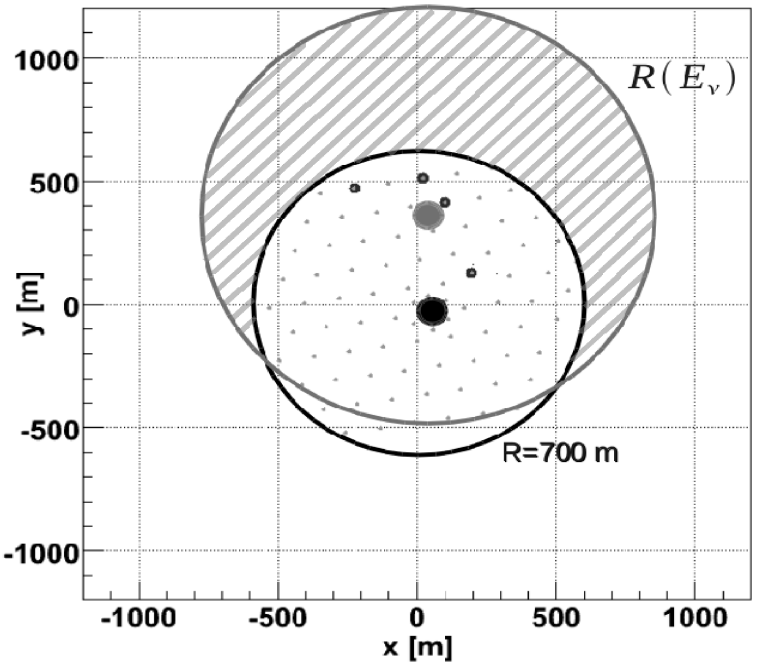
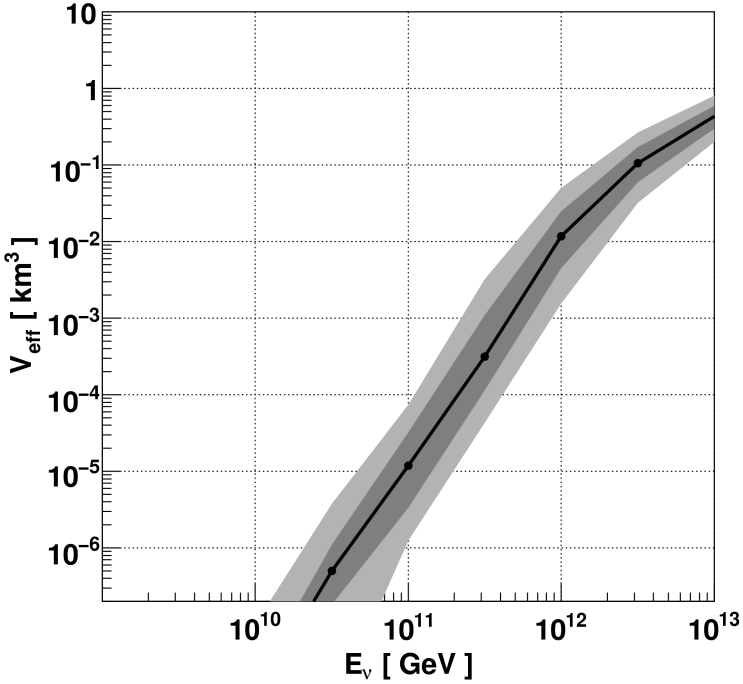
SPATS neutrino flux limit



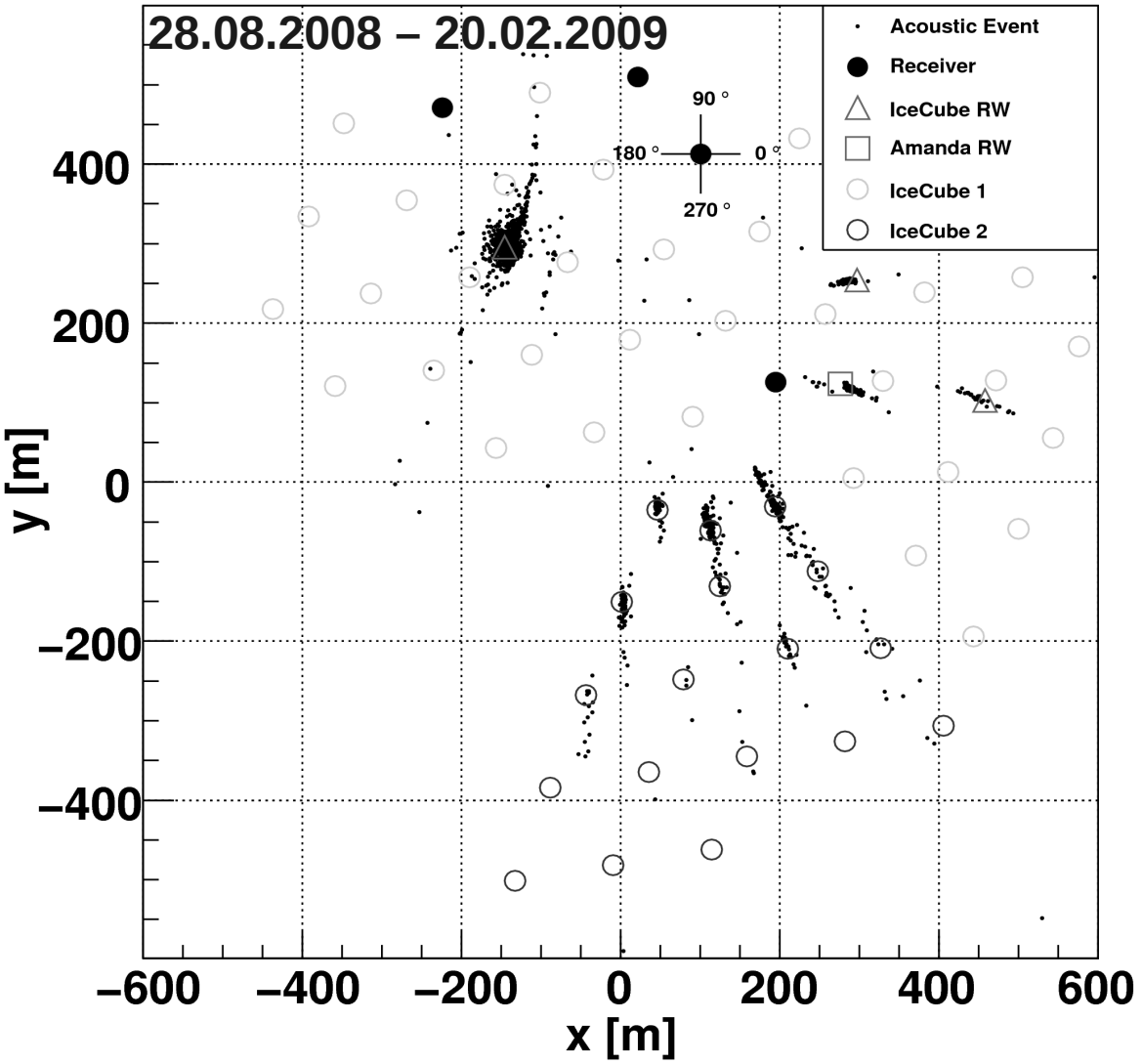


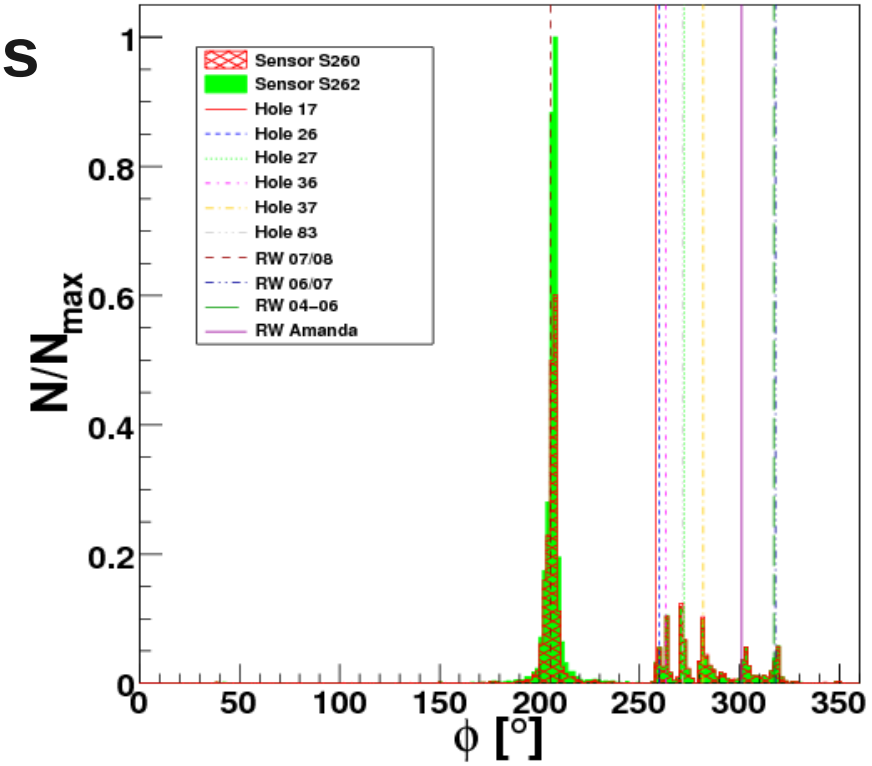


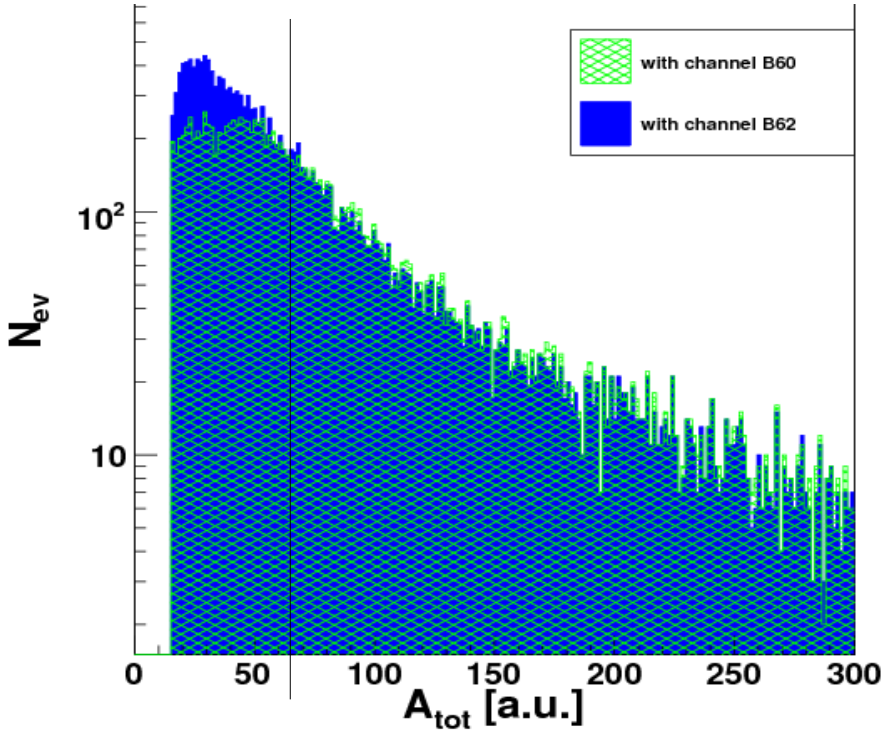
arXiv:astro-ph/1103.1216 accept. in APP

Single Sensor multi-channel studies

Full position information of localized transient events allow to calculate their angle in respect to the position of channel B60 and B62

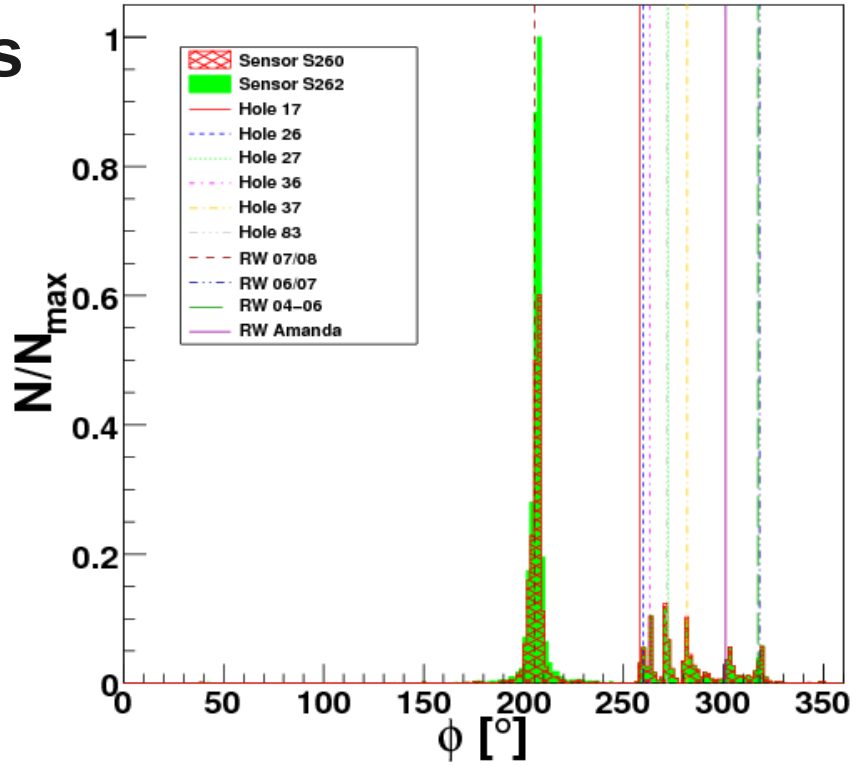


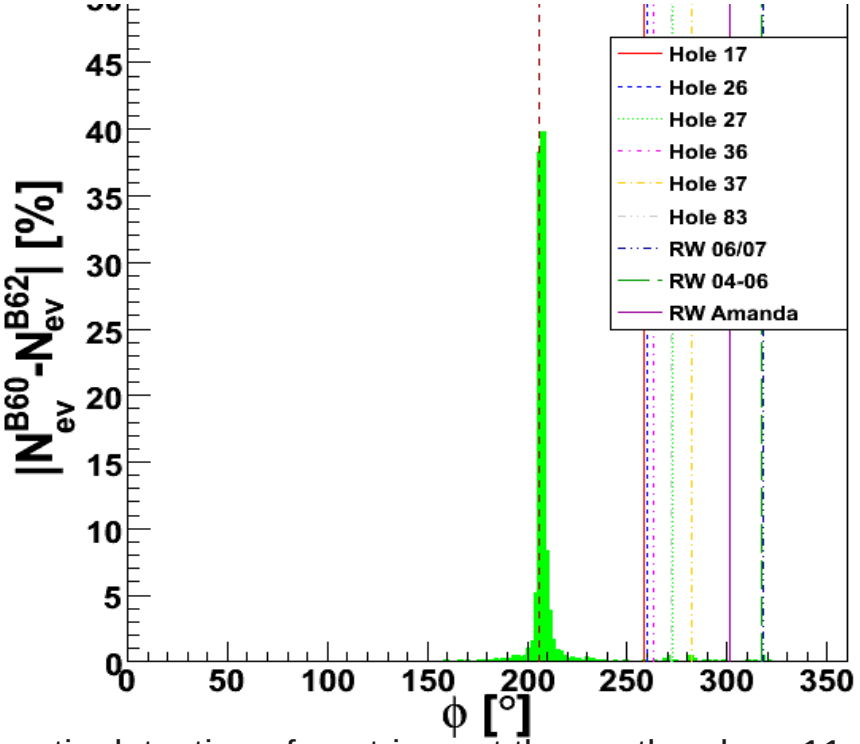




Single Sensor multi-channel studies

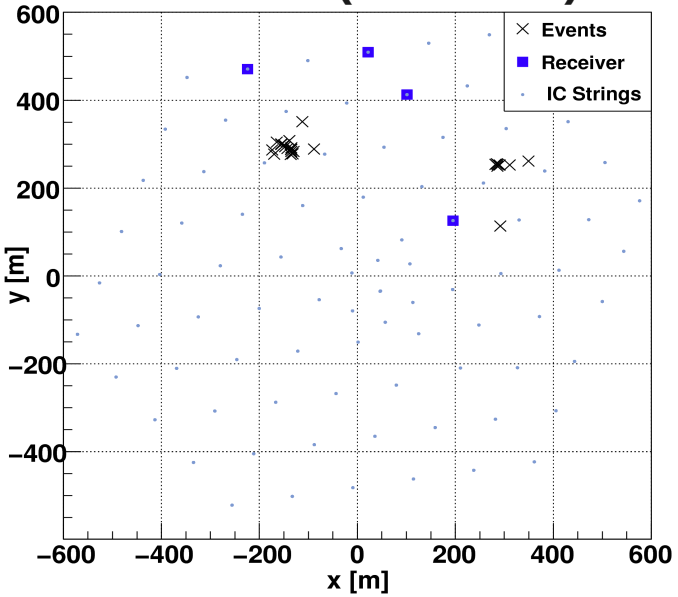
- **Both sensors on String B behave as expected over a wide azimuthal range (all holes and rodwells except RW07/08)**
- **Reduction of signals at sensor B60 in the φ range compared to B62 around RW07/08 might come from a shadowing effect (e.g. IceCube cable)**
- **Both channels get the same rate of hits for RW07/08 above a certain signal strength**
- **Hopefully more information soon from analysis of mobile transmitter (Pinger) data**



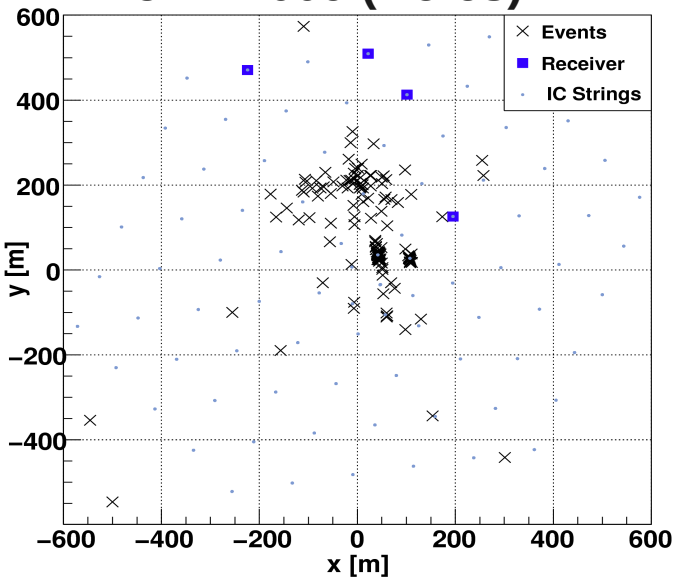


Transient frequency spectra

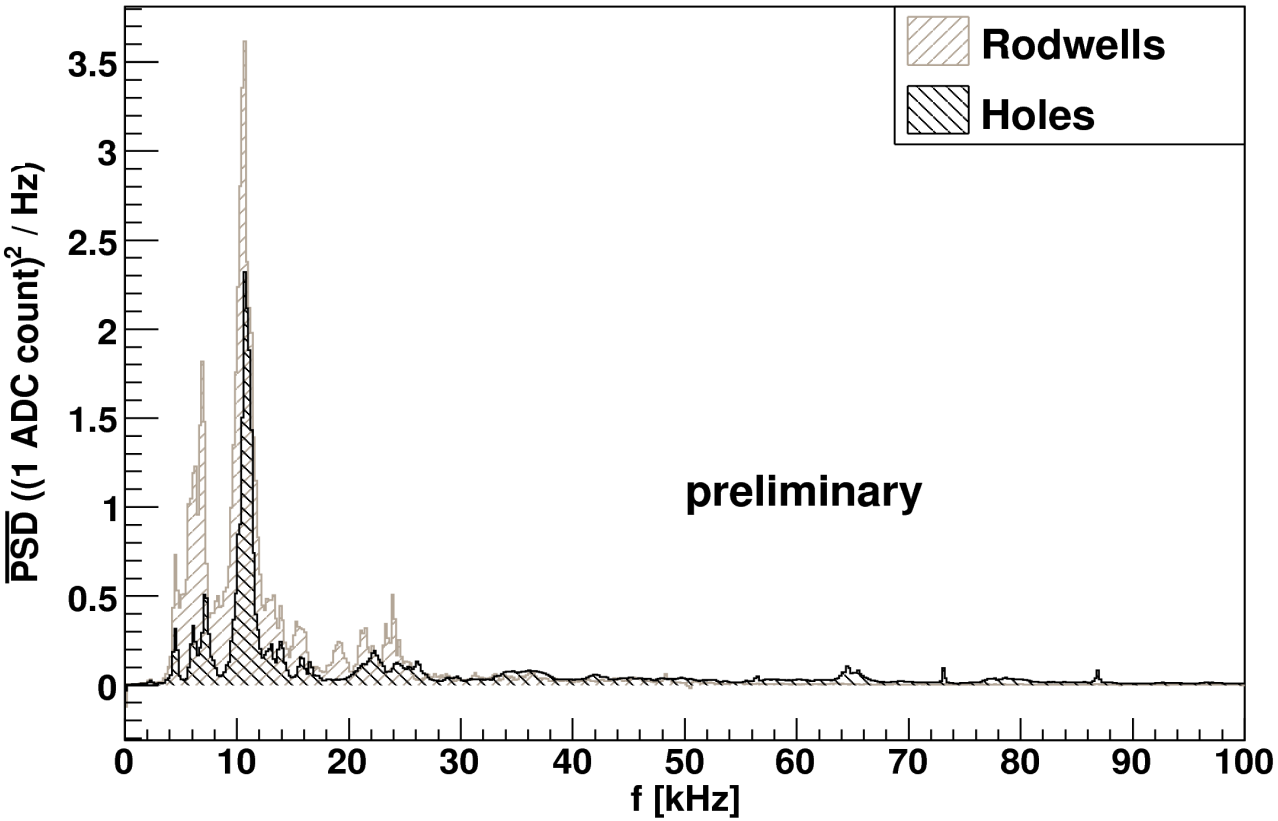
28.08.2008 (Rodwells)



25.12.2009 (Holes)

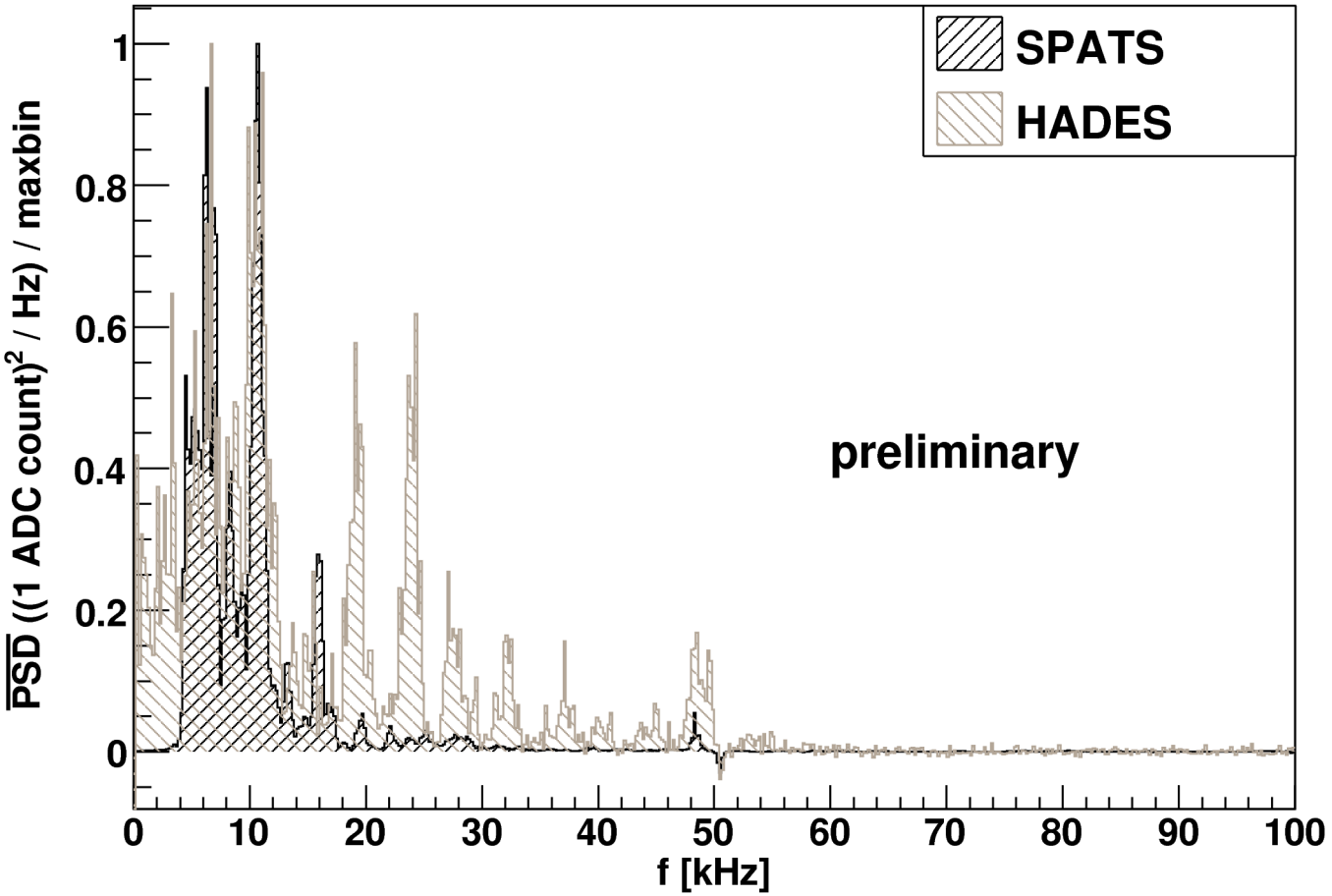


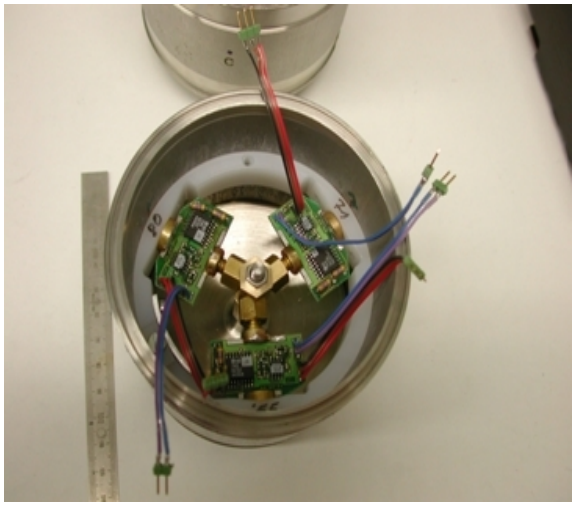
- Acoustic signals from rodwells have significant more low frequency components compared to hole events
  --> large relaxation volume reduces pressure/stress and can therefore damp an outgoing acoustic signal
- Signals from holes have small peaks at higher frequencies
  --> feature from refreezing process

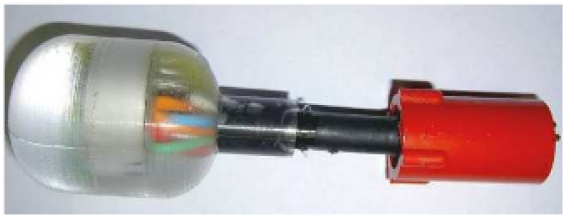


Transient frequency spectra

SPATS and Hades sensor have an entirely different construction, but show peaks at the same frequencies (e.g. 7,11,16,20,49 kHz).







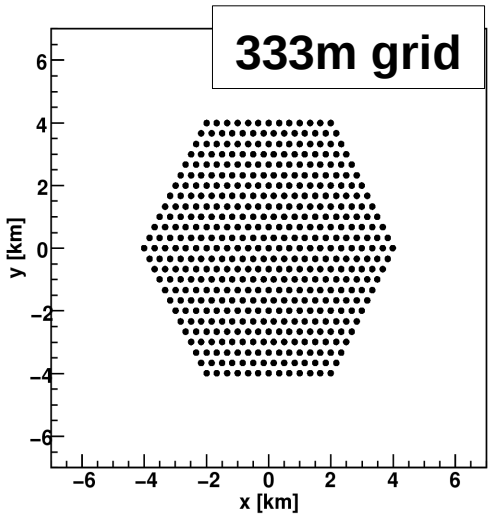
Therefore these peaks are an indication for a real frequency content from transient events.

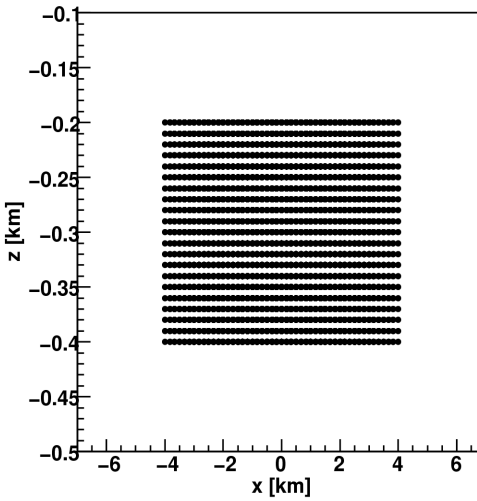
Hybrid radio-acoustic detector simulations

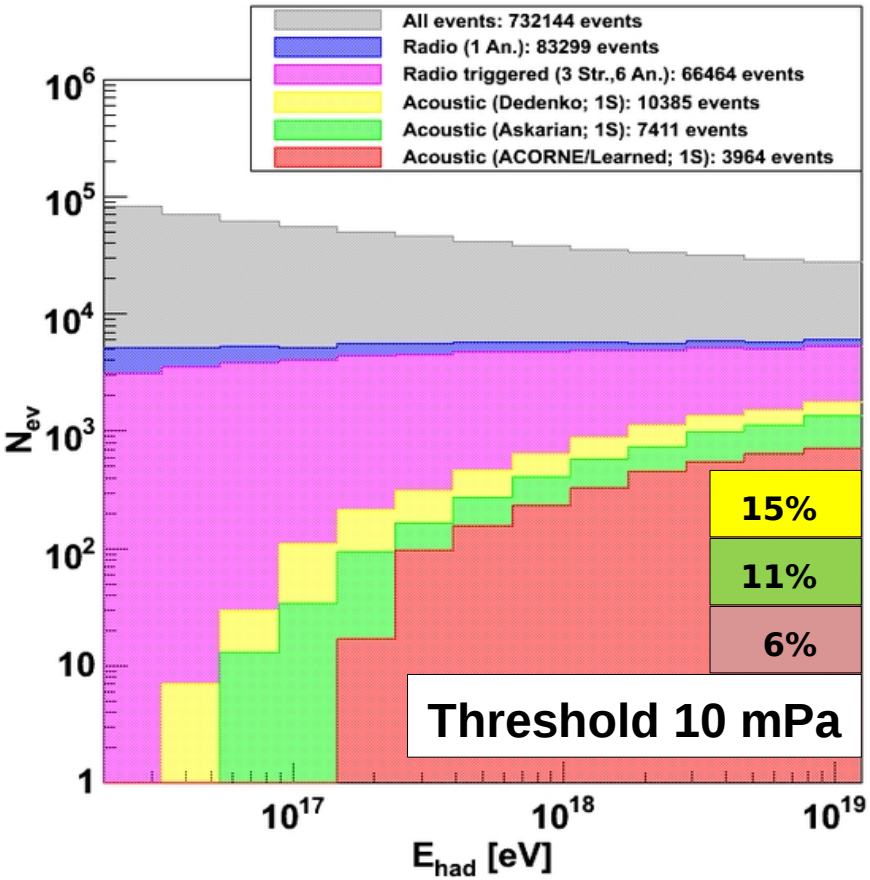
Acoustic additions

<u>SATRA detector simulation</u> (K.Hanson 2011)

- 469 holes, 4 pairs of dipols (LF,HF)
- trigger condition: >2 strings, >5 hits
- about 10% of radio events have additional acoustic signal
- ~80% of those give own acoustic trigger







<u>Detector deployment requirements</u>

- 100 – x000 strings
  - in about 5 years
    (with only a ~3-4 month per year available)
  - string distance 300 - 1500 m
  - string area 100 - 10000 km²
  - string depth 200 - 1000 m
  - hole diameter 4 - 8 inch

Robotic or quasi-robotic deployment scheme needed!