

HADES

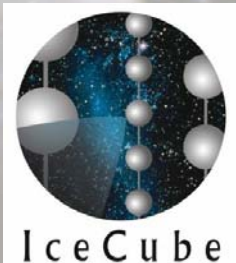
Hydrophone for Acoustic Detection at South Pole

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for the IceCube Acoustic Neutrino Detection Working Group



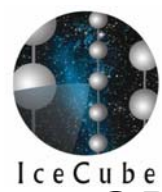
ARENA 2008 Workshop
Session 9
June, 27th 2008



- **Motivation**
- **Development of HADES**
 - **Acoustic impedance matching**
- **Deployment & first cry**



bmb:f · Förderschwerpunkt
Astroteilchenphysik
Großgeräte der physikalischen
Grundlagenforschung



Motivation

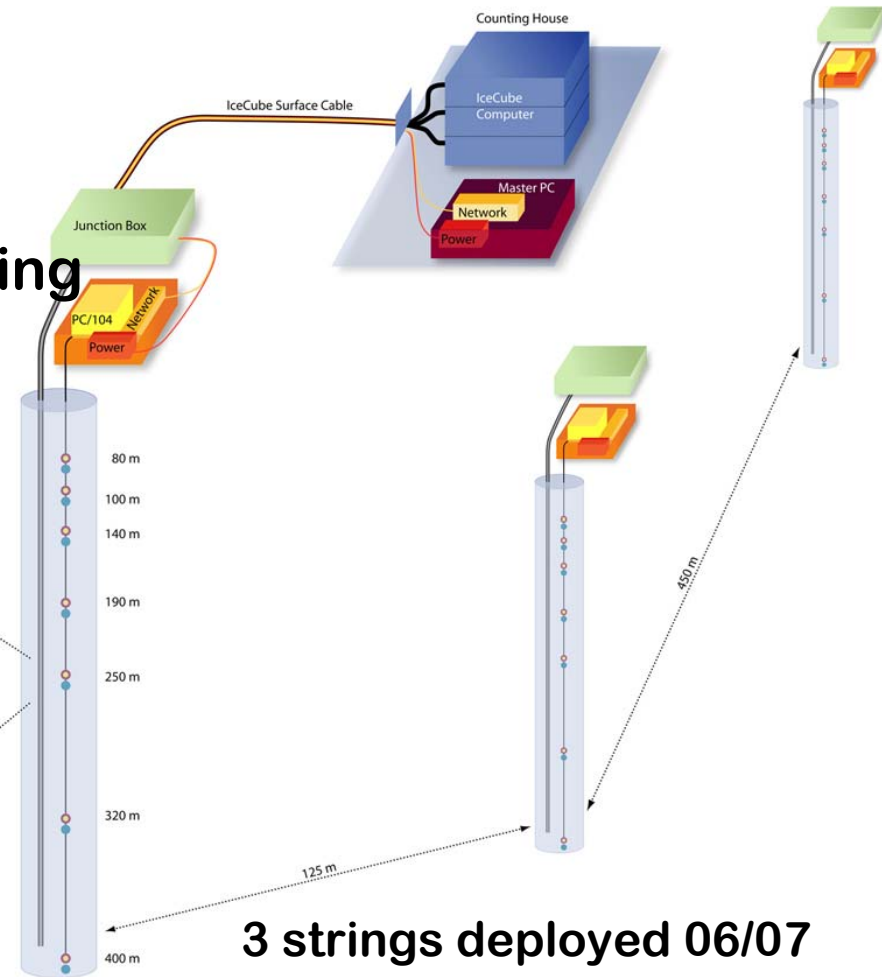
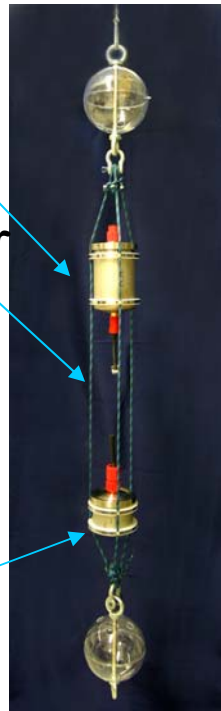


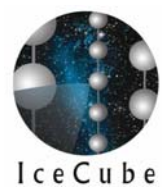
- **SPATS = South Pole Acoustic Test Setup**
- **Sensors that are alternative to the standard SPATS design**
 - **Different dynamical range**
 - **Different systematics**
 - **Different signal transmission**
 - **Based on SPATS sensor housing**

Transmitter housing

Transmitter

Sensor housing



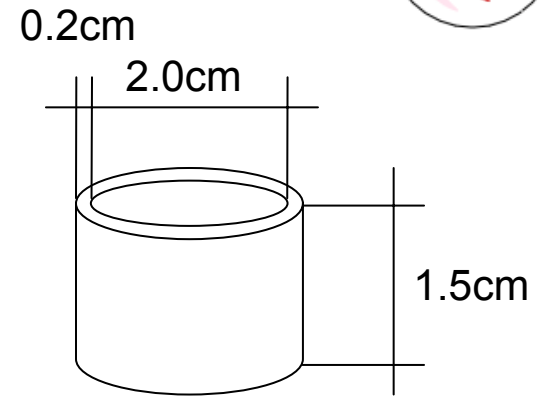


Development of HADES



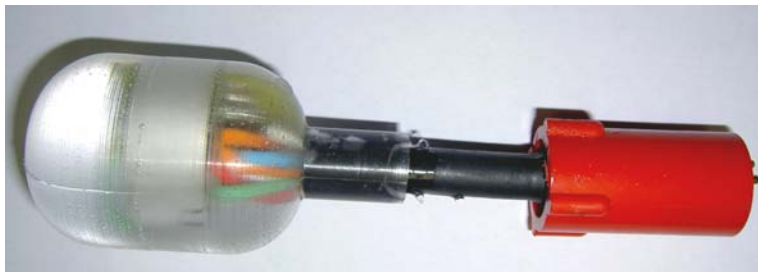
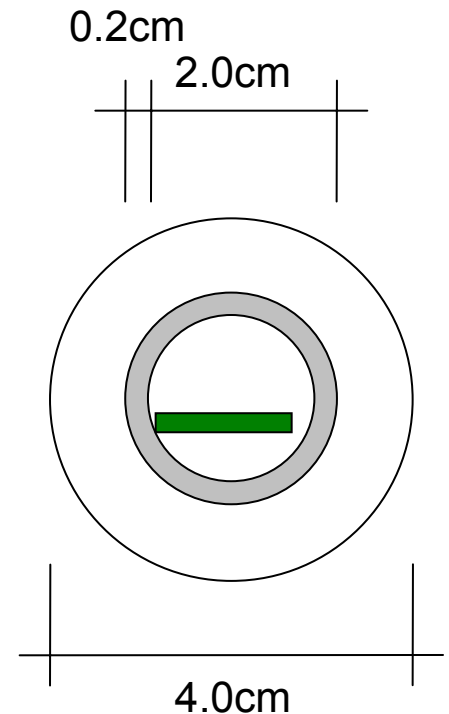
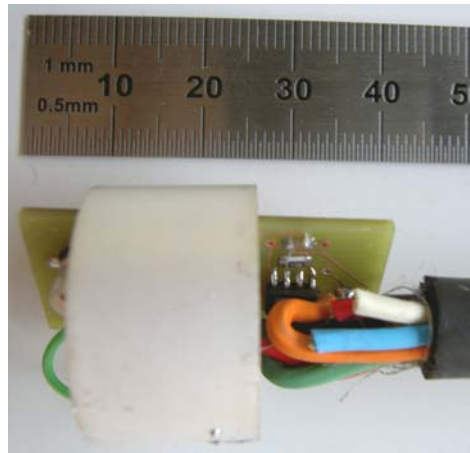
Ring piezo:

- **HADES A**
- **HADES B**
- **Pz-26 (hard PZT)**
- **Pz-27 (soft PZT)**

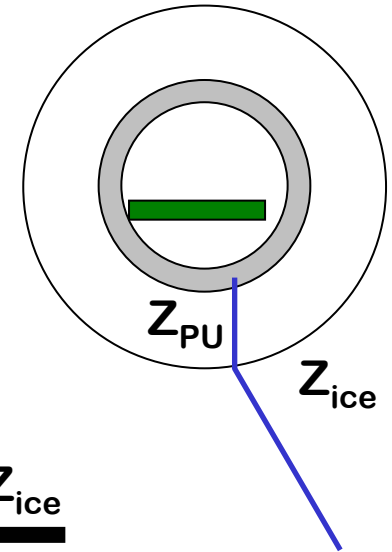
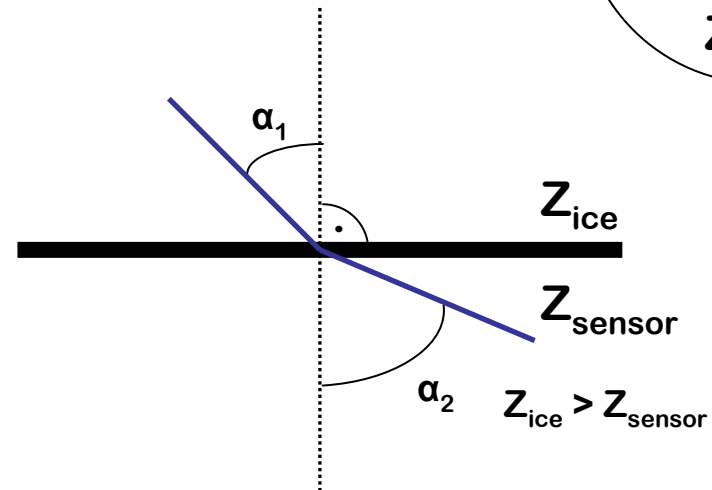
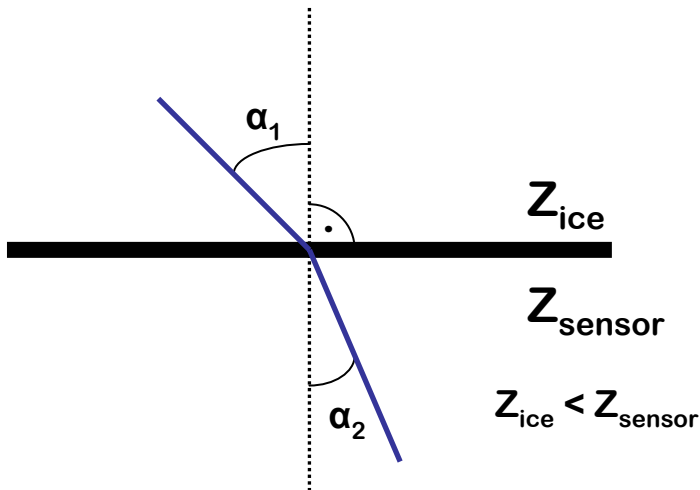


Amplifier:

- **2 stage amplification**
- **Type : Ti TL072**
- **Differential signal**



- Acoustic impedance: $Z_a = \rho * V_{\text{sound}}$
- Acoustic impedance corresponds to refraction index in optics

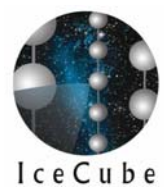


- Match impedance of ice and resin to maximize signal transmission

- **4 types of casting resins were tested**
 - Epoxy resin
 - Polyester resin
 - “Soft” Polyurethane resin
 - “Hard” Polyurethane resin

- **Produced test rod**
 - Measured signal transit time
 - Measured density
(determined by mass & volume)



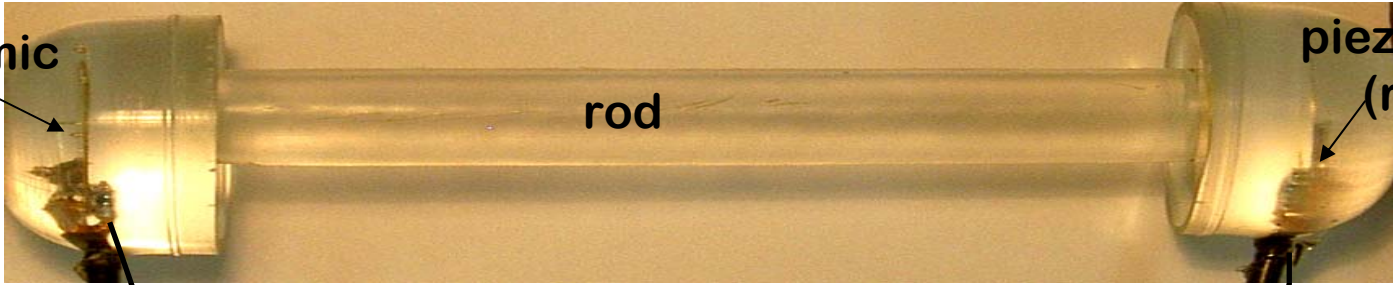


IceCube

Acoustic impedance matching



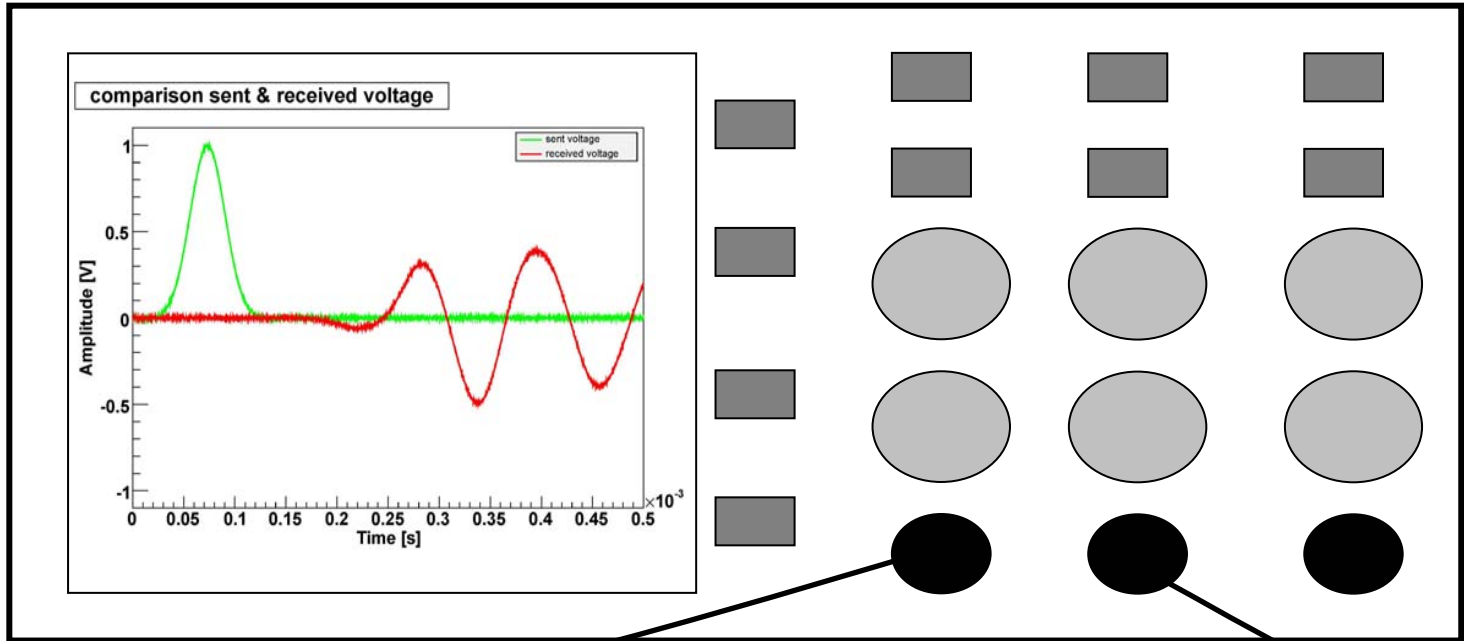
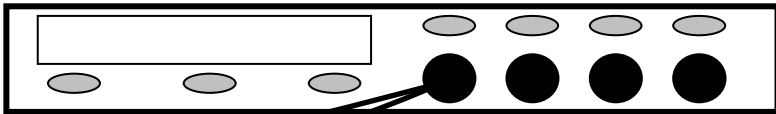
piezo-ceramic (send)



rod

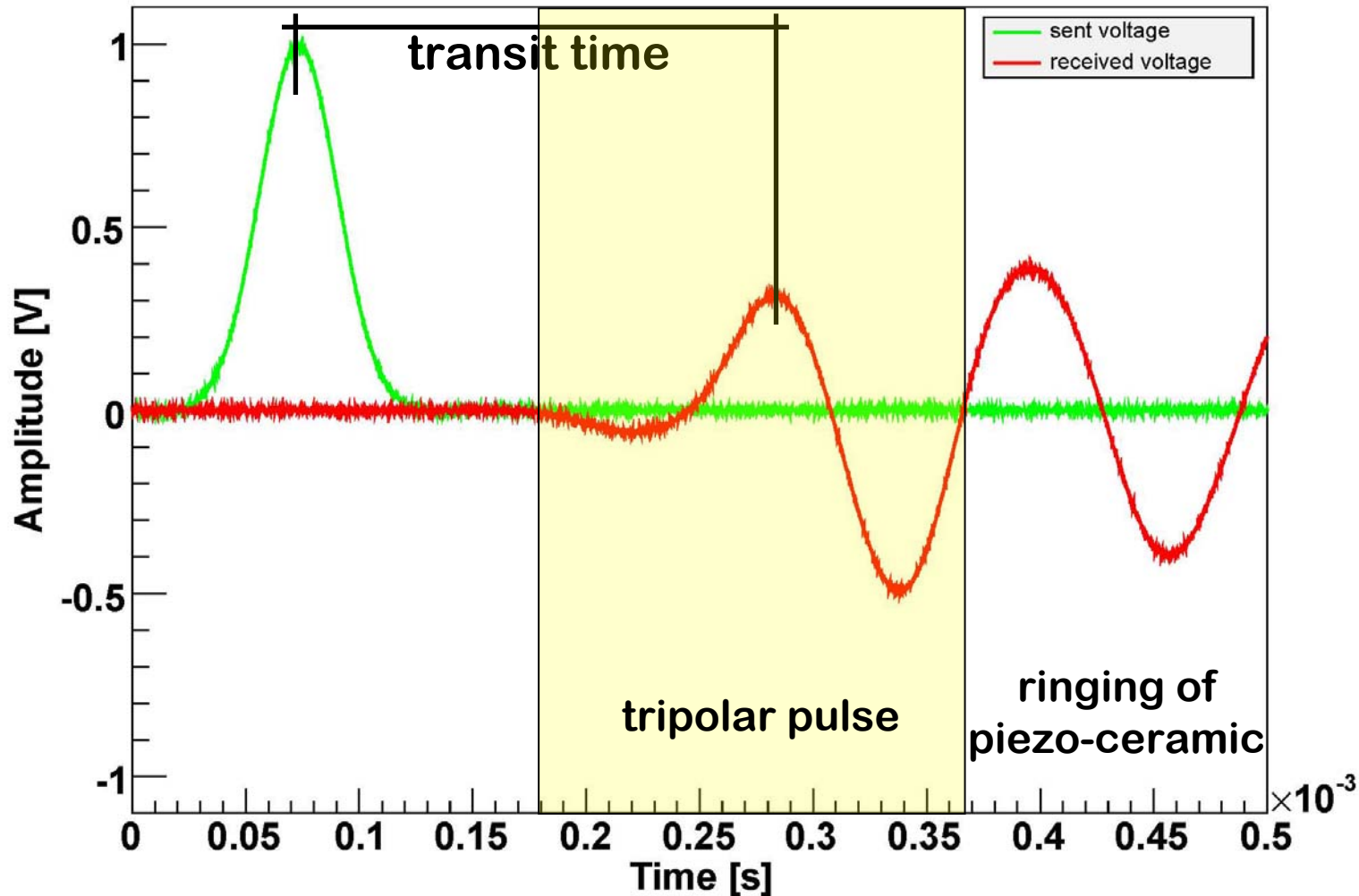
piezo-ceramic (receive)

pulse generator

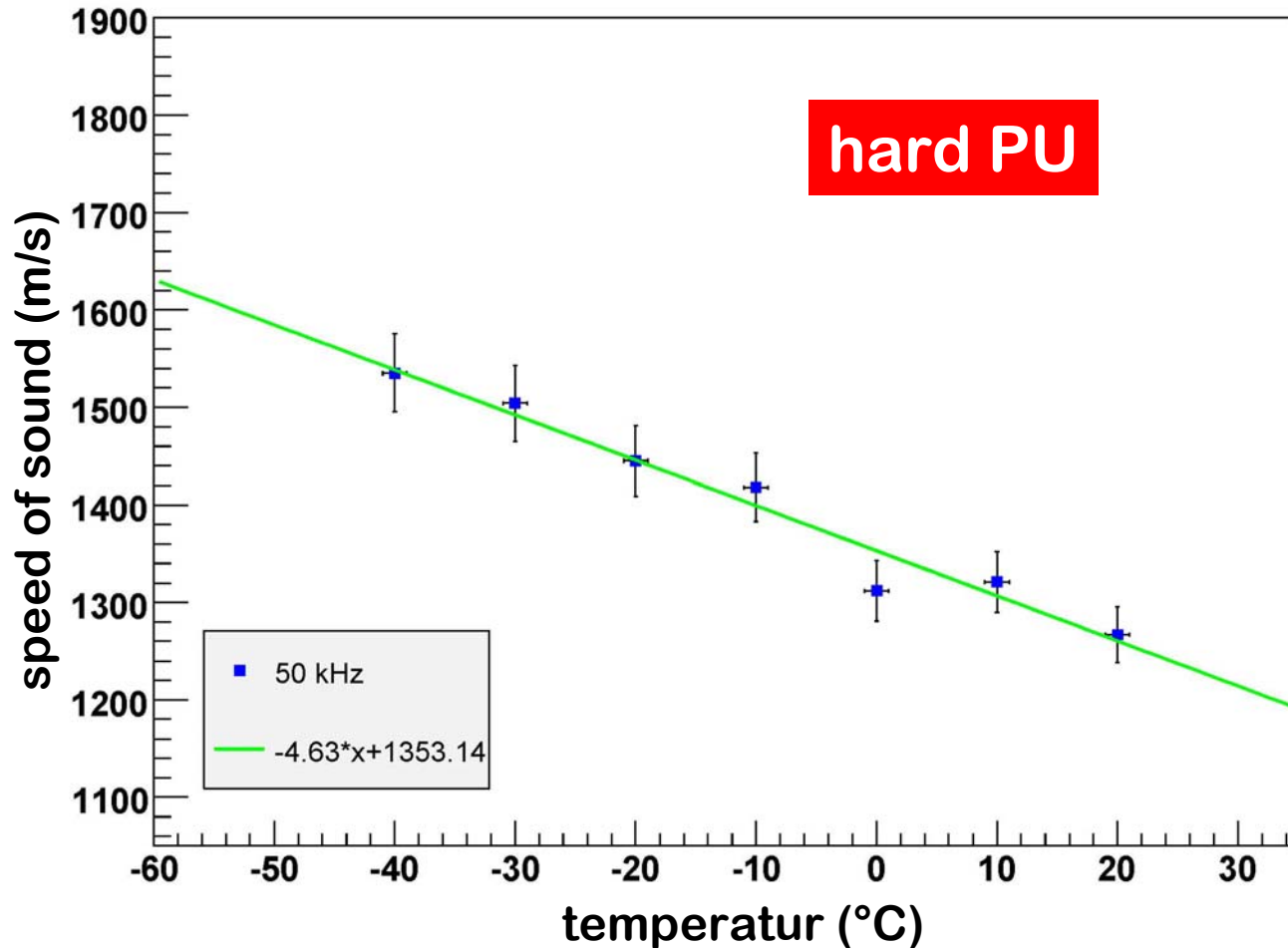


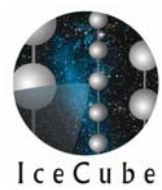
oscilloscope

comparison sent & received voltage



- Measured speed of sound vs. temperature in climate chamber

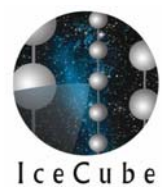




Acoustic impedance matching

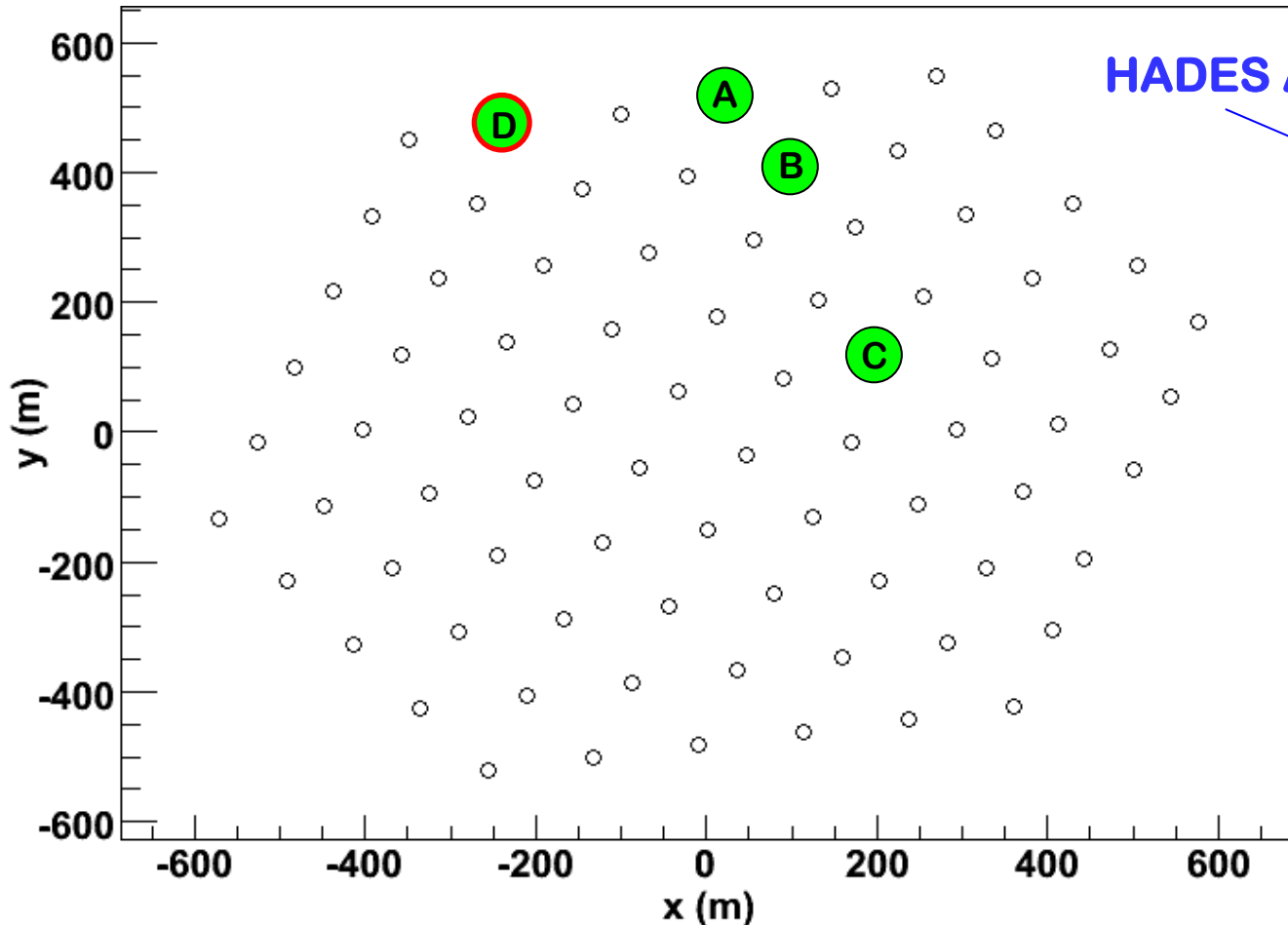


- 4 types of casting resins were tested
 - ☹️ Epoxi resin **did not pass -50°C air temperature test**
 - ☹️ Polyester resin **did not pass -50°C air temperature test**
 - ☹️ “Soft” Polyurethane resin **has lower acoustic impedance in comparison with ice than hard PU**
 - 😊 “Hard” Polyurethane resin
 $Z(-50^{\circ}\text{C}) = 1836 \pm 88 \text{ kNs/m}^3$
- Ice: $Z(-50^{\circ}\text{C}) = 3606 \text{ kNs/m}^3$ Steel: $Z = 40086 \text{ kNs/m}^3$



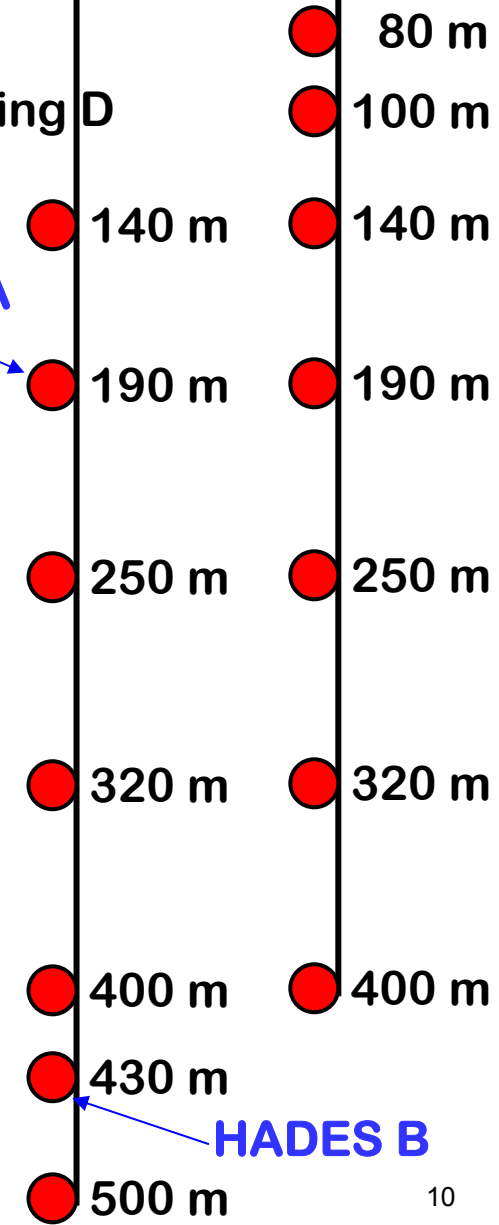
HADES deployed on String D

- **String D deployment: 24.12.07**
 - **two HADES sensors**



String D

String A, B, C



HADES A

HADES B

String D Deployment

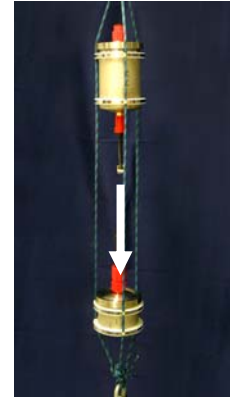
- **HADES B (level 6)**



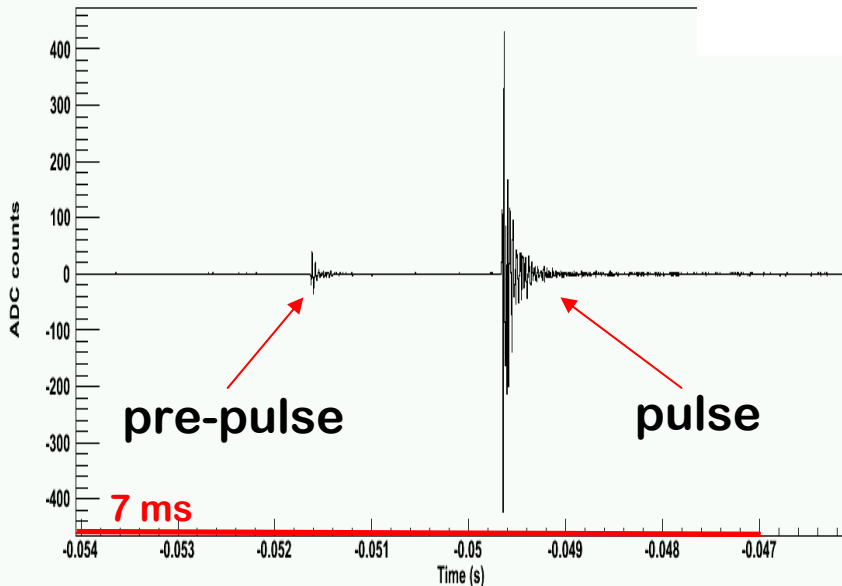
- **HADES A (level 2)**



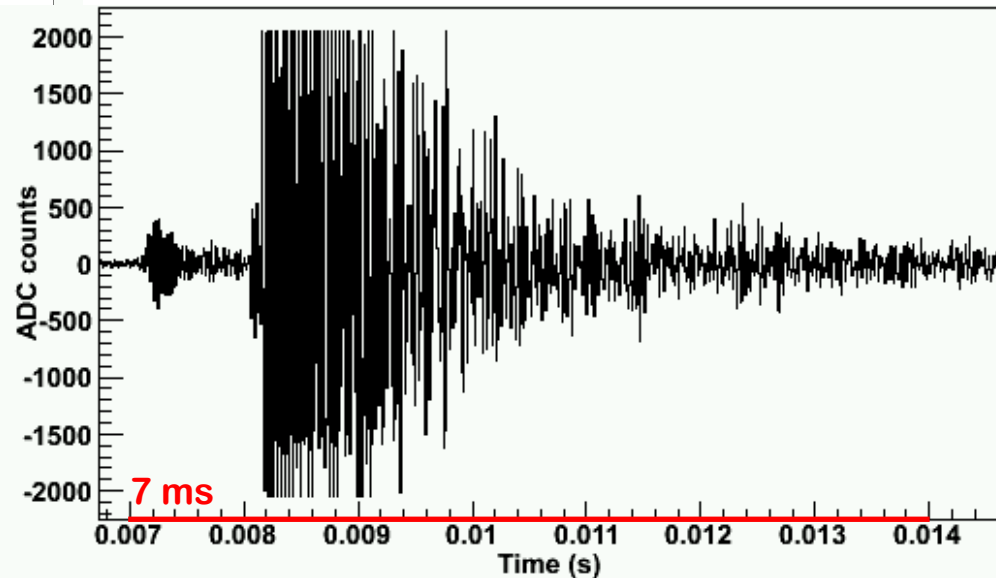
- Sent intra-stage pulses
 - Only possible at stages with HADES sensors, because all other stages (with SPATS sensors) are in saturation

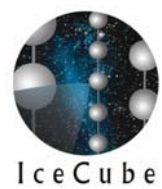


HADES B L6 (depth: 430 m)



SPATS sensor L5 (depth: 400 m)



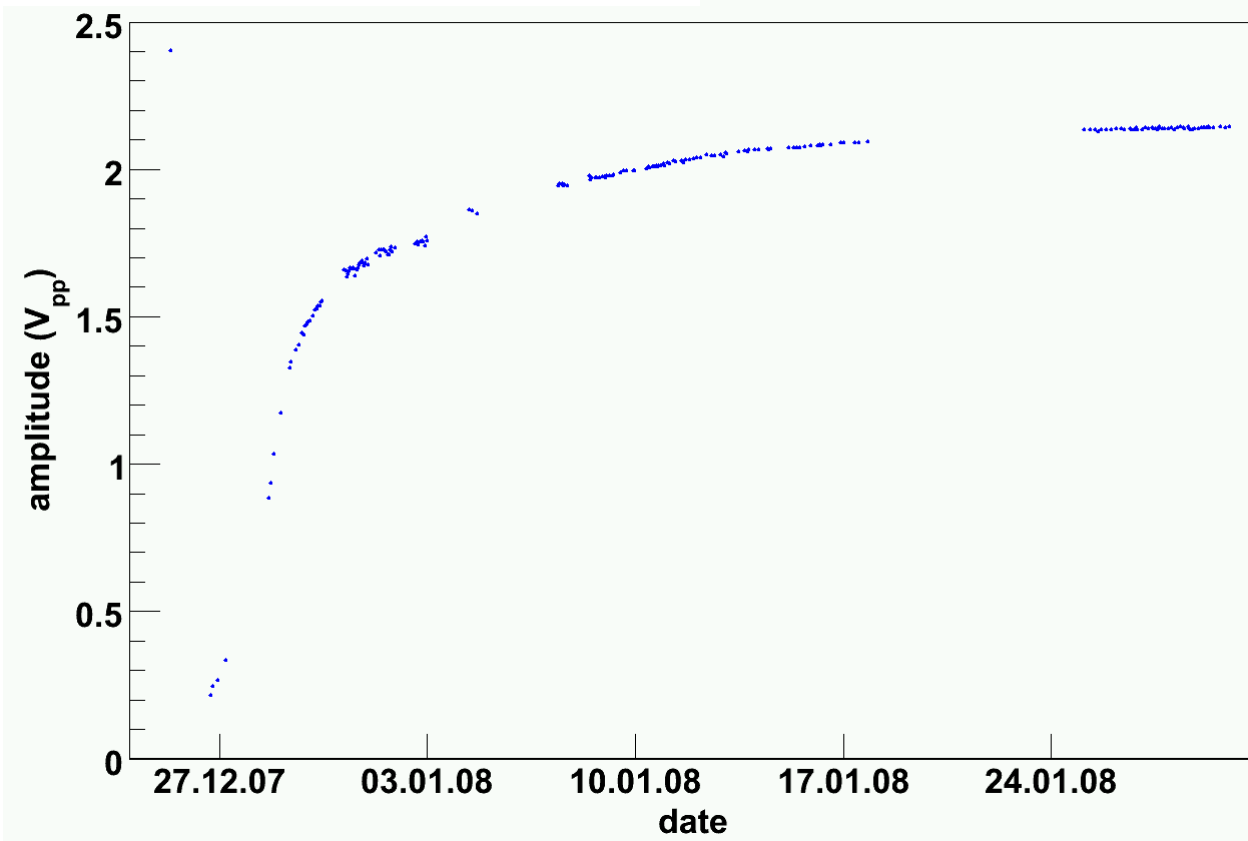


Did we see the freeze in ?



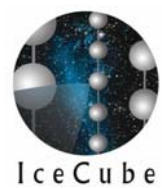
- **Amplitude variation with time**
 - Increase in sensitivity due to temperature decrease
 - Better acoustic coupling to ice instead of water

HADES B L6 (depth: 430 m)





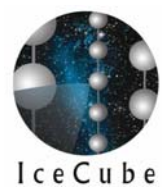
- **Diameter: 2.5 m**
- **Height: 2.3 m**
- **1 x bottom ring**
 - inner height: 0.35 m
 - weight: 2150 kg
- **4 x shaft ring**
 - inner height: 0.50 m
 - weight: 1180 kg (each)
- **Water volume: ~11 m³**



Water Tank Test Facility



- **Planned beginning of operation: after meeting**
- **Measurement of the sensor sensitivity dependence on zenith and azimuth angle improves the attenuation analysis**
- **Sensor calibration will allow to determine absolute noise level in deep South Pole ice**
 - **Two HADES sensors (similar to the deployed sensors at Pole) are ready for laboratory tests**
 - **Additionally two are currently under construction**



Summary & Outlook



- **HADES is an alternative sensor for SPATS**
- **Development and deployment of HADES**
- **First cry**
 - **Hole ice formation after freeze in**
- **Water Tank Test Facility**
 - **Calibration**
 - **Investigate the angular dependence of sensitivity**

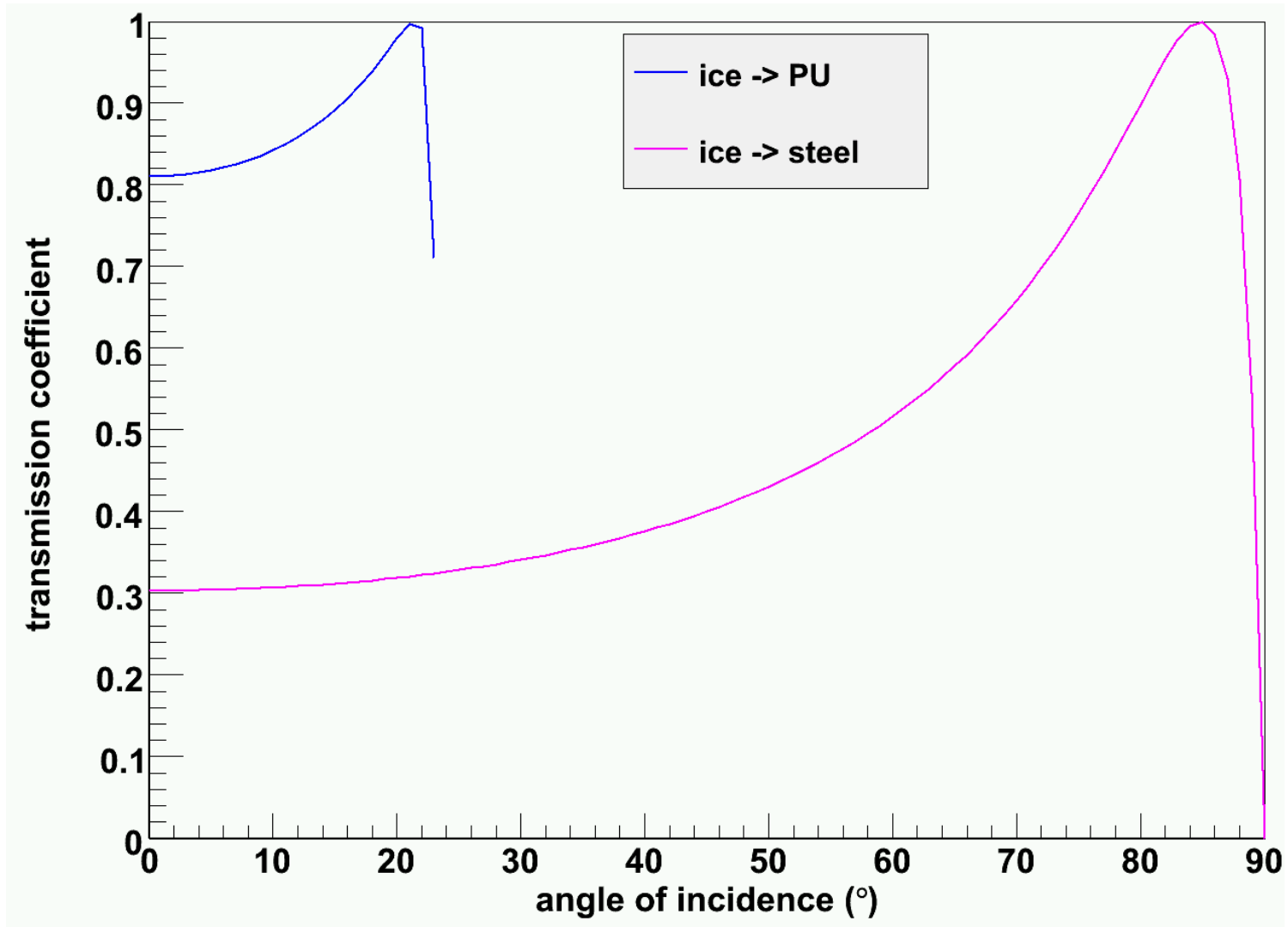


Thank you for your attention!



Back up slides

Transmission





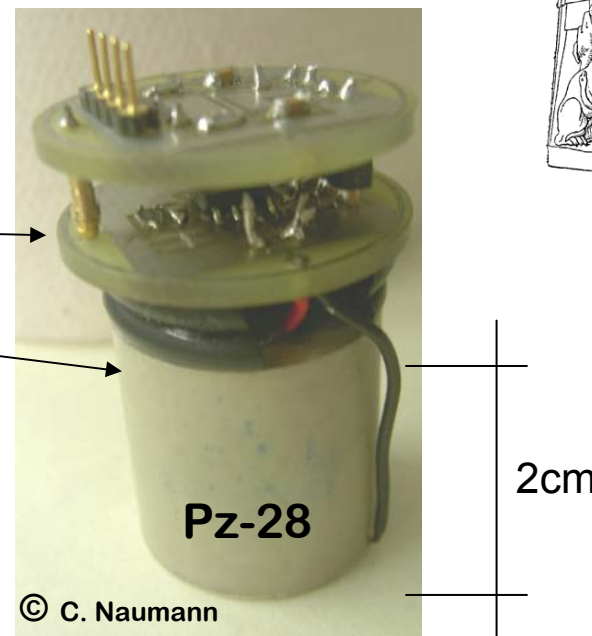
Production of HADES



- **HADES = Hydrophone for acoustic detection at South Pole**

- **Consists of three elements**

- **Amplifier**
- **Piezo-ceramic**
 - ❖ 62.5 kHz resonant frequency
- **Coated by hard PUR (black colored)**



Produced by Christopher Naumann at University of Erlangen-Nürnberg. Erlangen-Nürnberg produces acoustic sensors for ANTARES



Production of HADES

- SPATS sensor housing
- Contains the voltage converter



- Only add a connector to standard SPATS housing

