

# SAUND II

**Study of Acoustic Ultra-high energy Neutrino Detection  
Phase II**

**Naoko Kurahashi  
Stanford University**

# SAUND II: People Involved

## Collaborators

### Stanford University

- Giorgio Gratta
- Naoko Kurahashi



### University of California, Berkeley

- Justin Vandenbroucke
- 



### Naval Postgraduate School

- Daphne Kapolka
- Michael Gruell



### Princeton University

- Cristiano Galbiati



## Support

### Naval Undersea Warfare Center, (NUWC) United States Navy



- Trevor Kelly-Bissonnette
- Dave Deveau

.... and many other US Navy related people that supported us on base

# What Has Changed

Phase II means many things have changed from SAUND I....

- 1) The US Navy's AUTECH Hydrophone Replacement Program (AHRP)
- 2) Readout of full  $\sim 1000\text{km}^2$  hydrophone array scheduled
- 3) DAQ Architecture
- 4) Better than  $10\mu\text{s}$  time stamping across computers using IRIG-B signal feed ( $10\mu\text{s} = 1.5\text{cm}$ )



# Hydrophone System Replaced by Navy

## SAUND I System (Pre AHRP)

~30 yrs old system

**System:** Amplified at each phone, transmitted on copper cable to shore

**Sensitivity:** ~ 14Pa/V with fluctuations

**Response:** 7.5 kHz - 50 kHz  
(High pass filter in system)  
Flat to better than 8dB

**Gain Uniformity:** Large fluctuations over time,  
factor of few across channels

## SAUND II System (AHRP)

new system (~1yr old)

Amplified & digitized at each phone underwater, then transmitted on optical fiber

132dB/ $\mu$ Pa (~4Pa/V), Stable

50Hz - 40kHz  
Flat ~0dB

Better than 1dB across channels

# SAUND I Event Rate

TABLE 2  
EVENT RATES

Cut/Description	Events
1. Online triggers:	
<i>a)</i> Digital filter .....	64.6 M
<i>b)</i> Correlated noise .....	20.2 M
2. Quality cuts:	
<i>a)</i> Offline rethresholding.....	7.23 M
<i>b)</i> Offline quiet conditions.....	2.60 M
<i>c)</i> $\Delta t_0 > 1$ ms .....	2.56 M
3. Waveform analysis:	
<i>a)</i> Remove spikes .....	2.03 M
<i>b)</i> Remove diamonds.....	1.96 M
<i>c)</i> $f_e > 25$ kHz.....	1.92 M
4. Coincidence building:	
<i>a)</i> Coincidence .....	948
<i>b)</i> Localization convergence.....	79
5. Geometric fiducial region	0

Almost 2M of  
non-acoustic events!

J. Vandenbroucke et al., "Experimental Study of Acoustic Ultra-High-Energy Neutrino Detection"  
Astrophysical Journal, 621:301-312

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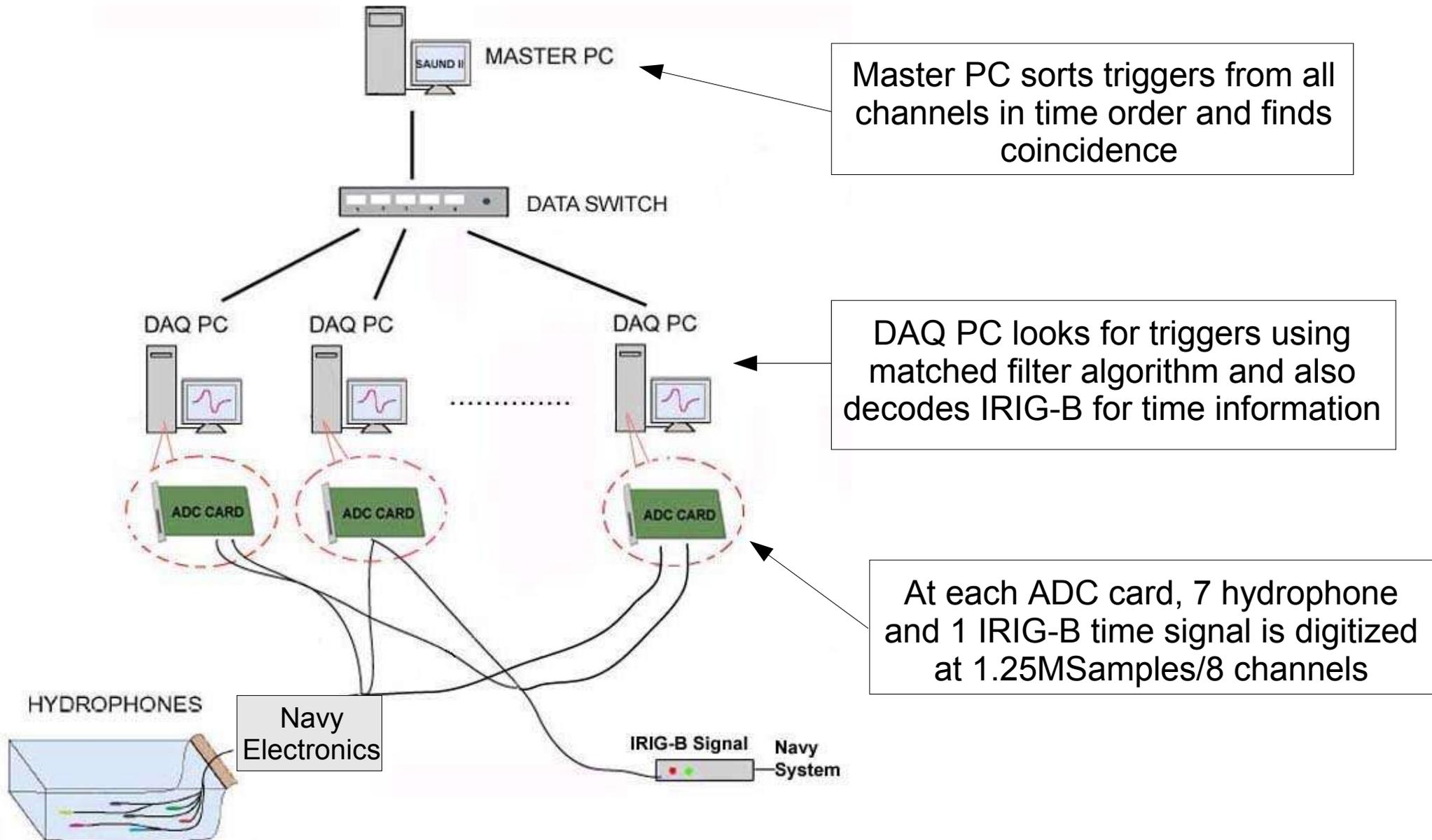
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# DAQ System Architecture



# KiNOKO, Comedi, and the Card

**OS:** Linux

**DAQ software:** Kinoko

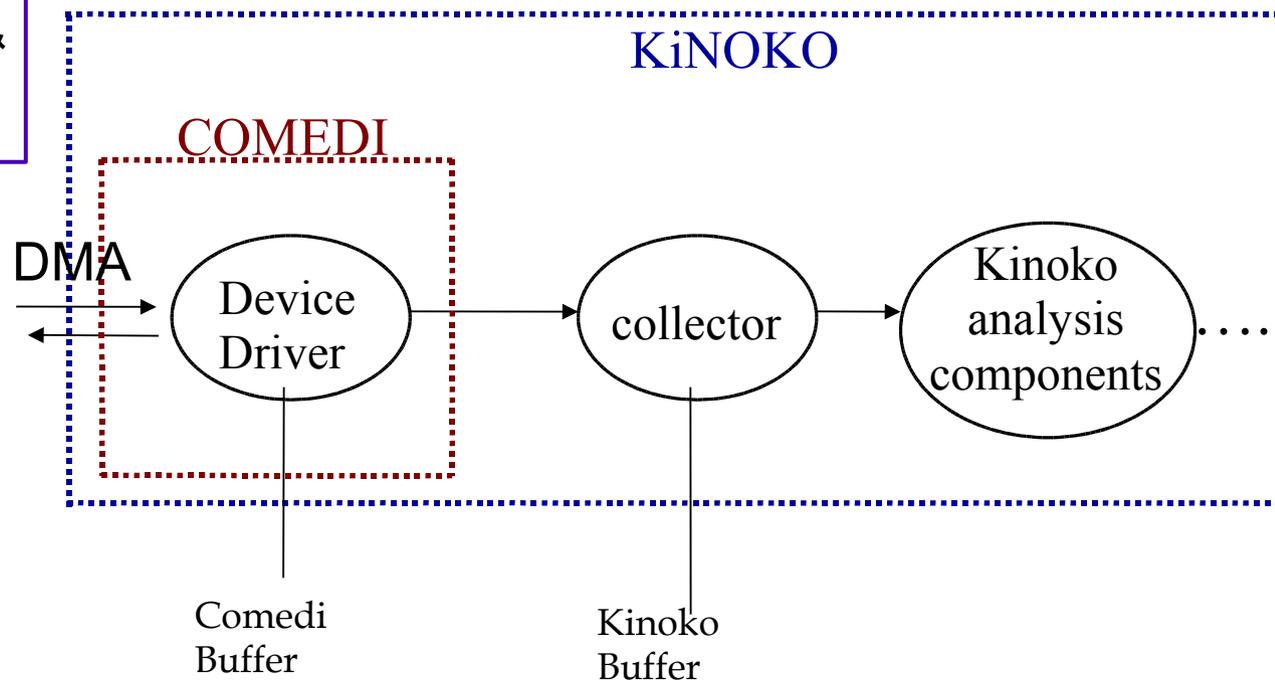
(general data acquisition system  
developed for KamLAND)

<http://www.awa.tohoku.ac.jp/~naoko/kinoko-e/>

**Card Interface:** COMEDI

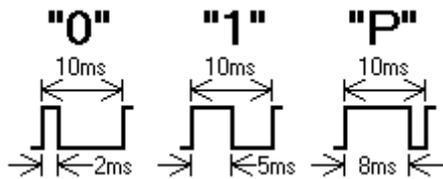
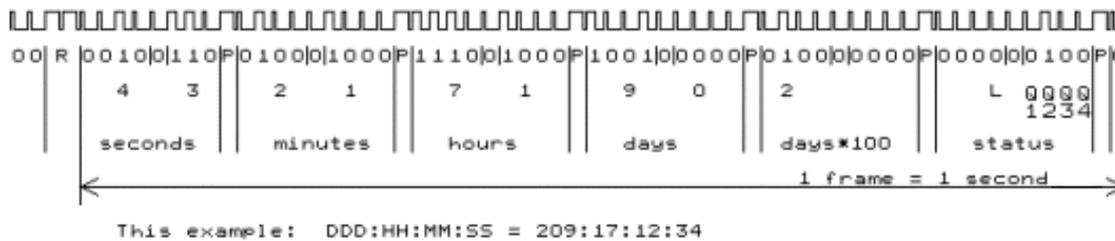
(Open source driver & library for ADC &  
DAC cards)

<http://www.comedi.org/>



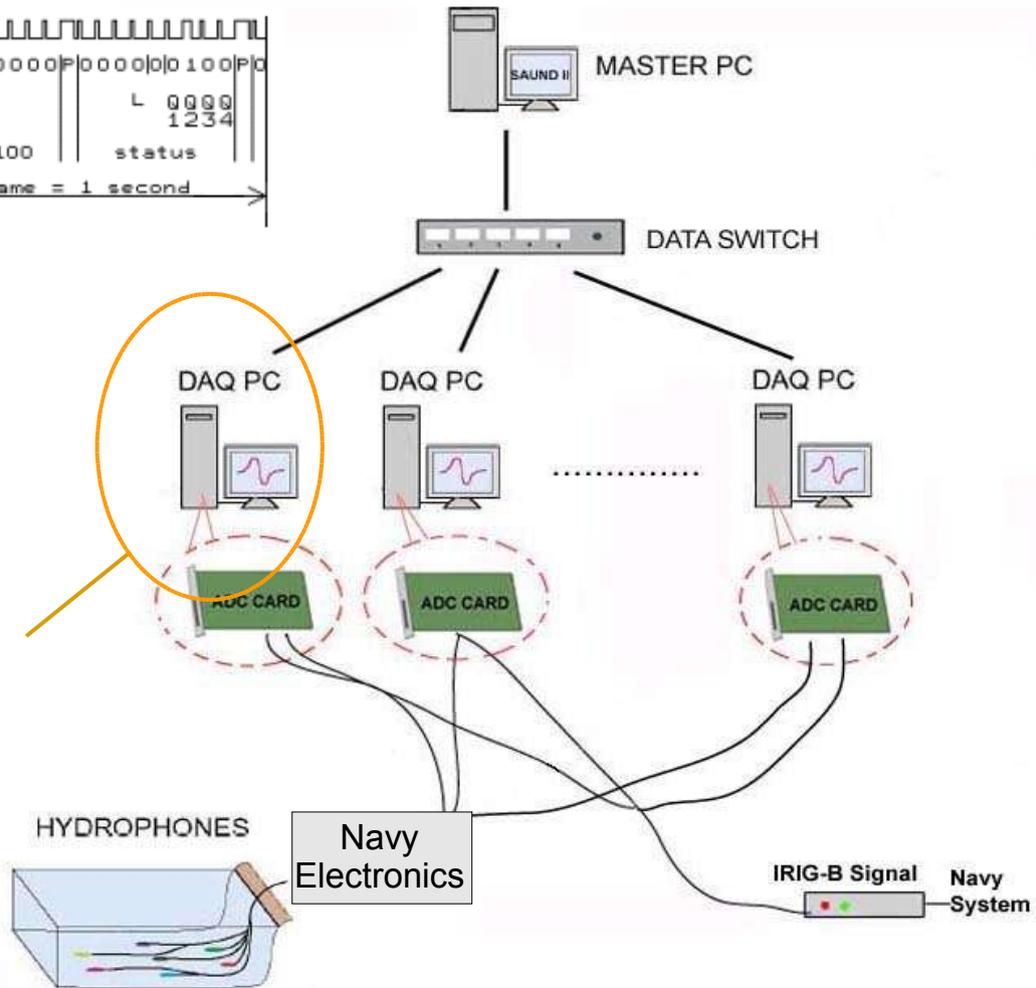
Latency can be up to ~1 min; need to resynchronize across computers  
and also across channels.

# IRIG-B for Accurate Time Information



Analyze IRIG-B Code That Came With Data At The Same Time For Time Information

➔ Better than 10μs accuracy across all channels!



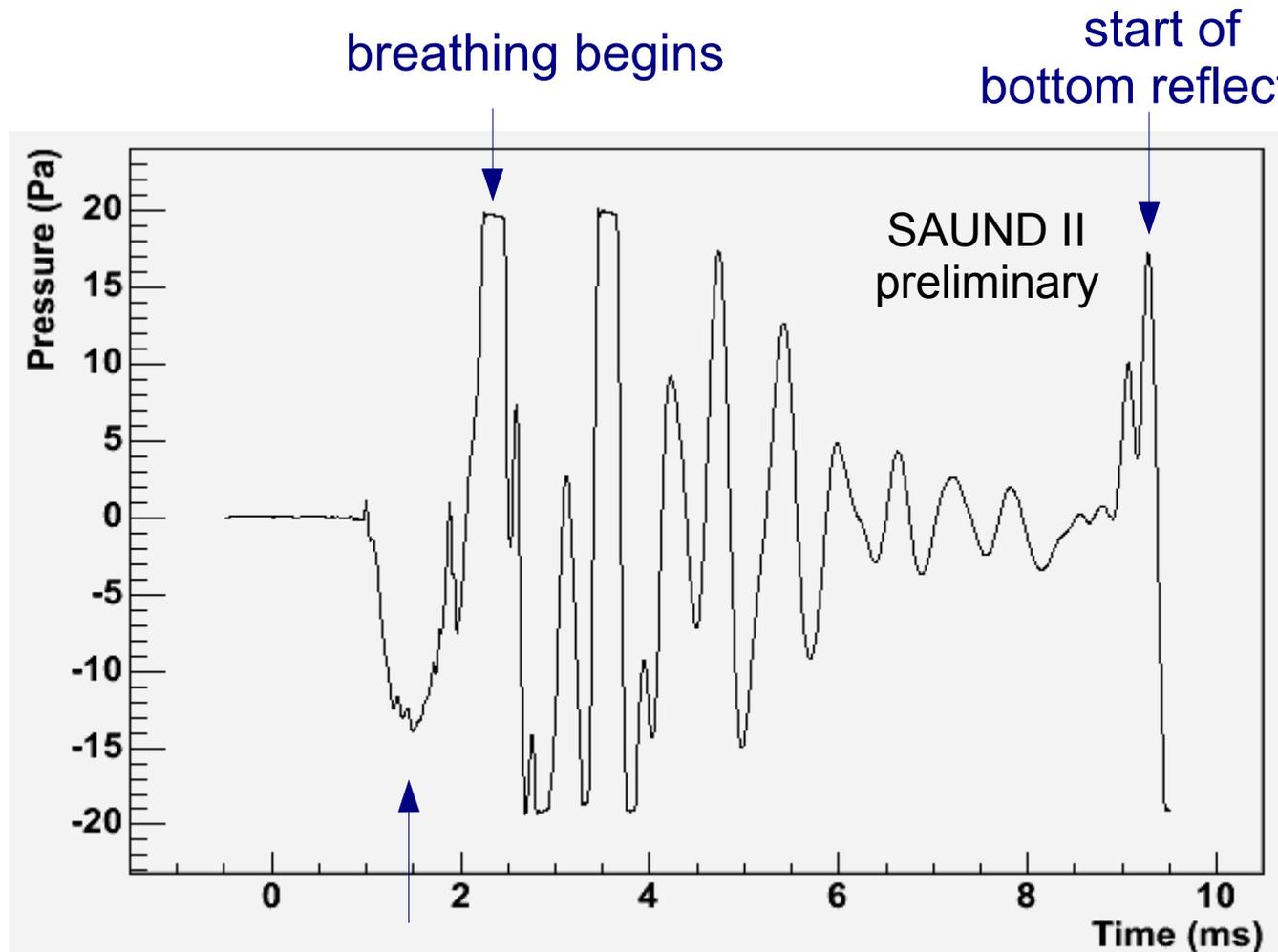
# 1<sup>st</sup> Installation Trip

## March 26<sup>th</sup> - April 1<sup>st</sup> 2005



International ARENA Workshop, May 19th 2005

# “Lightbulb Calibration”

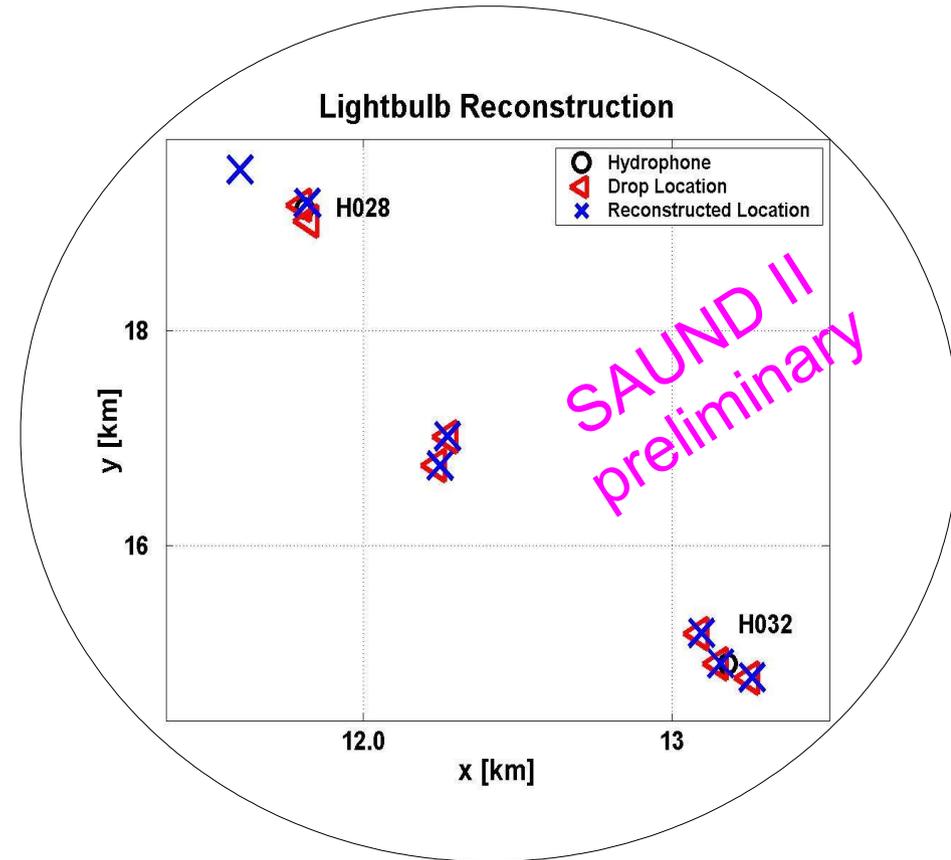
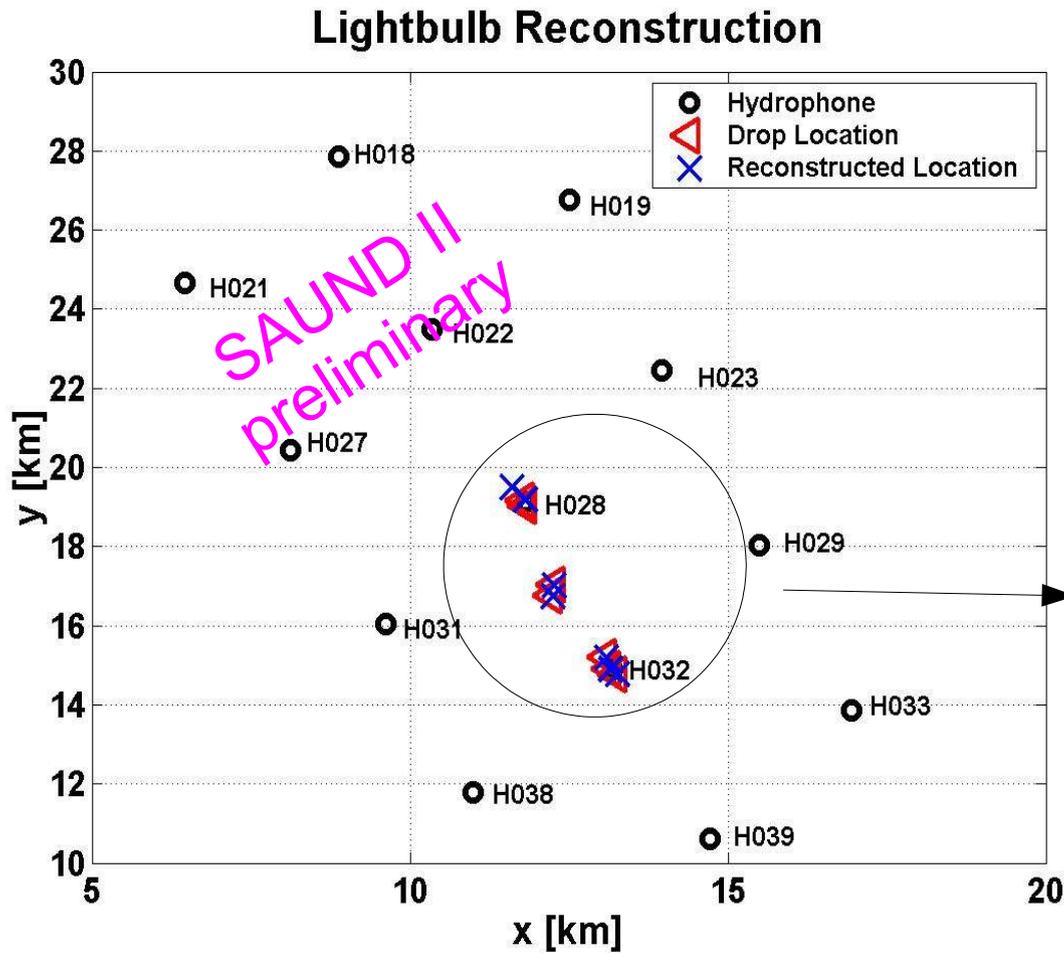


initial implosion

start of  
bottom reflection

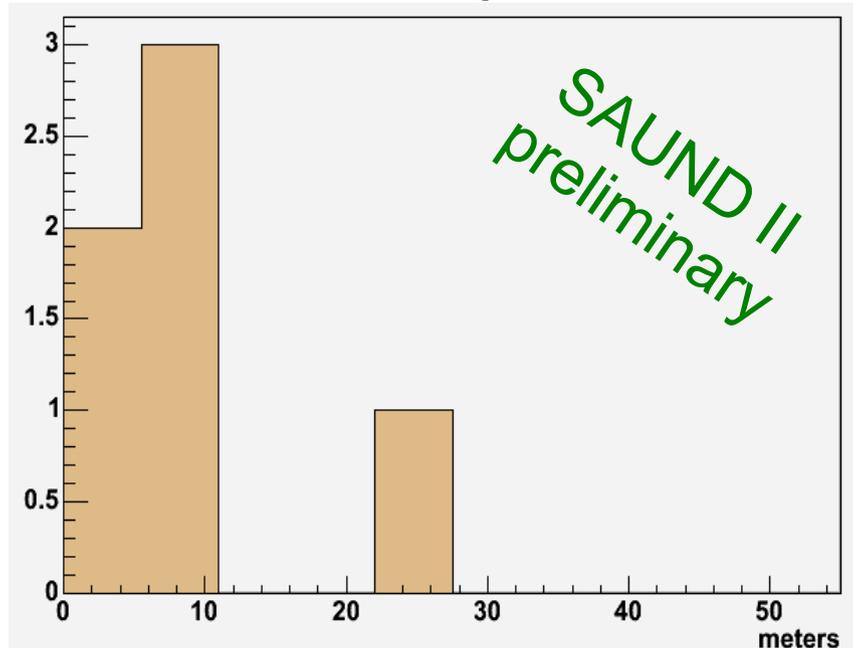


# “Lightbulb Calibration”



# “Lightbulb Calibration”

reconstruction and drop location difference



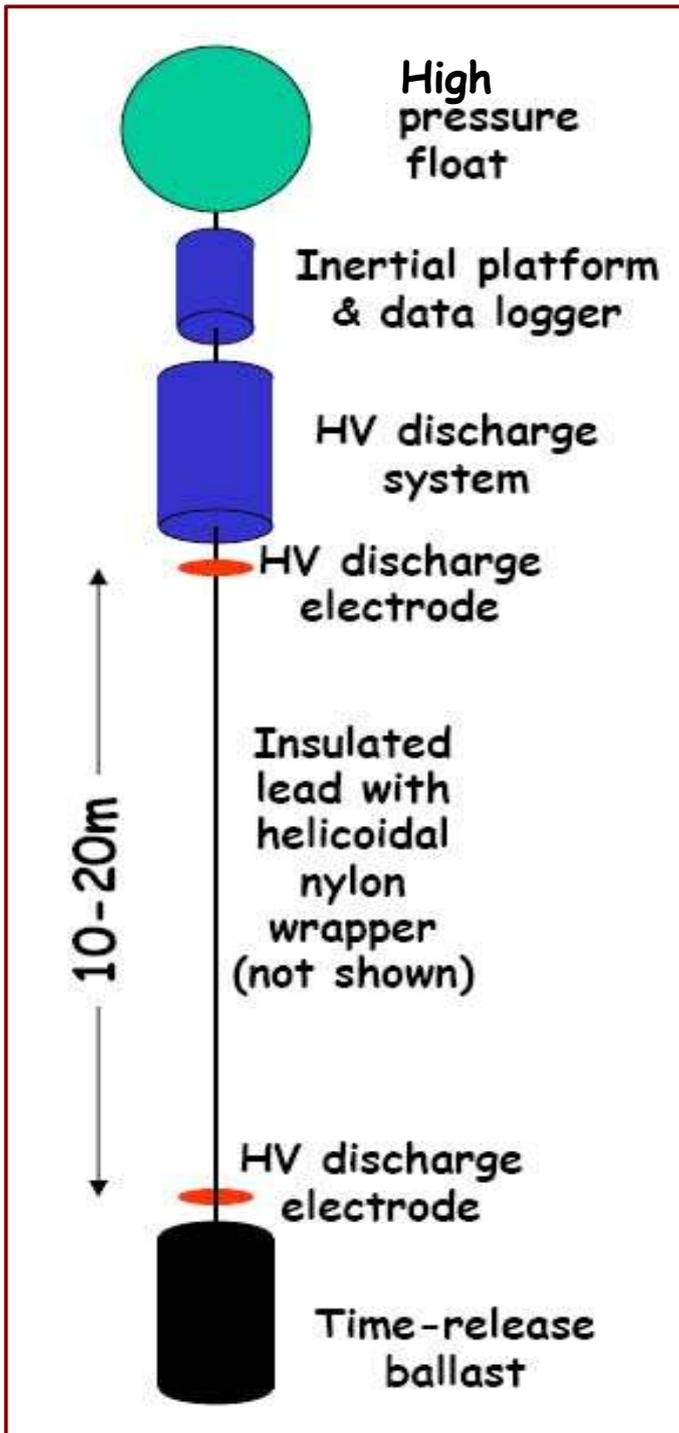
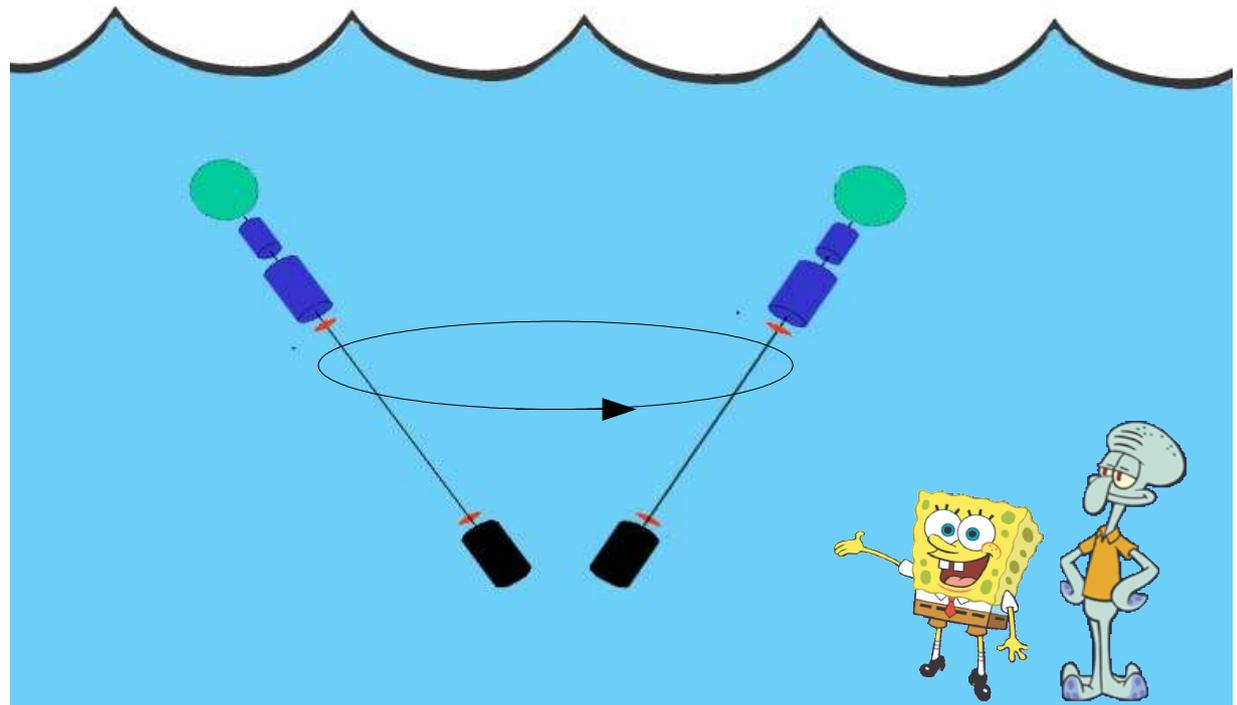
Most reconstruct to better than 10m

Lightbulb calibration shows that we are resynchronizing triggers with IRIG-B across channels correctly

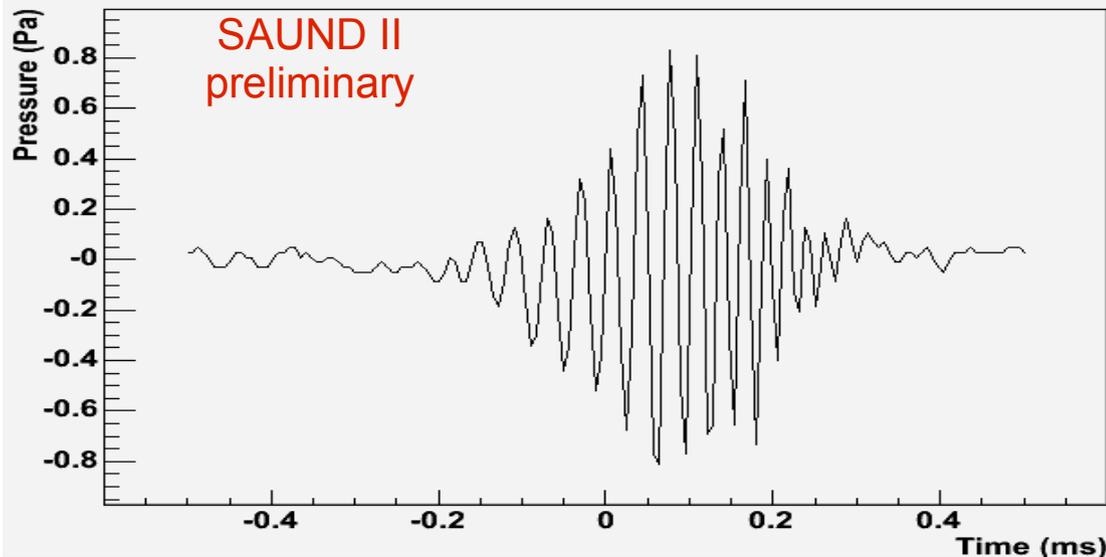
# Future “Zapper”

provides...

- Phase Calibration
- Linear Source Calibration

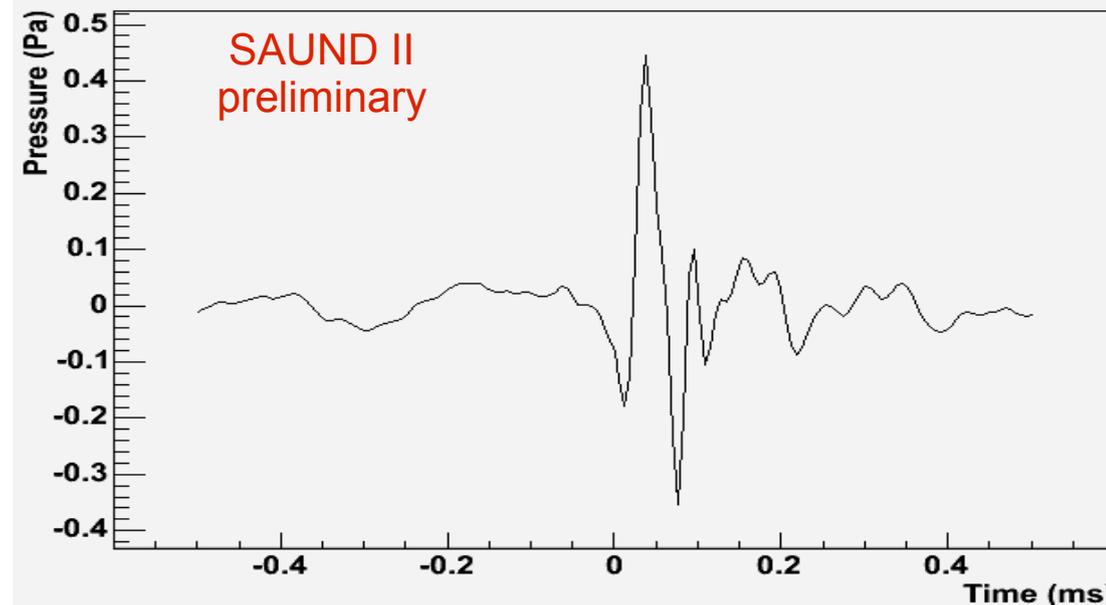


# Trigger Identification



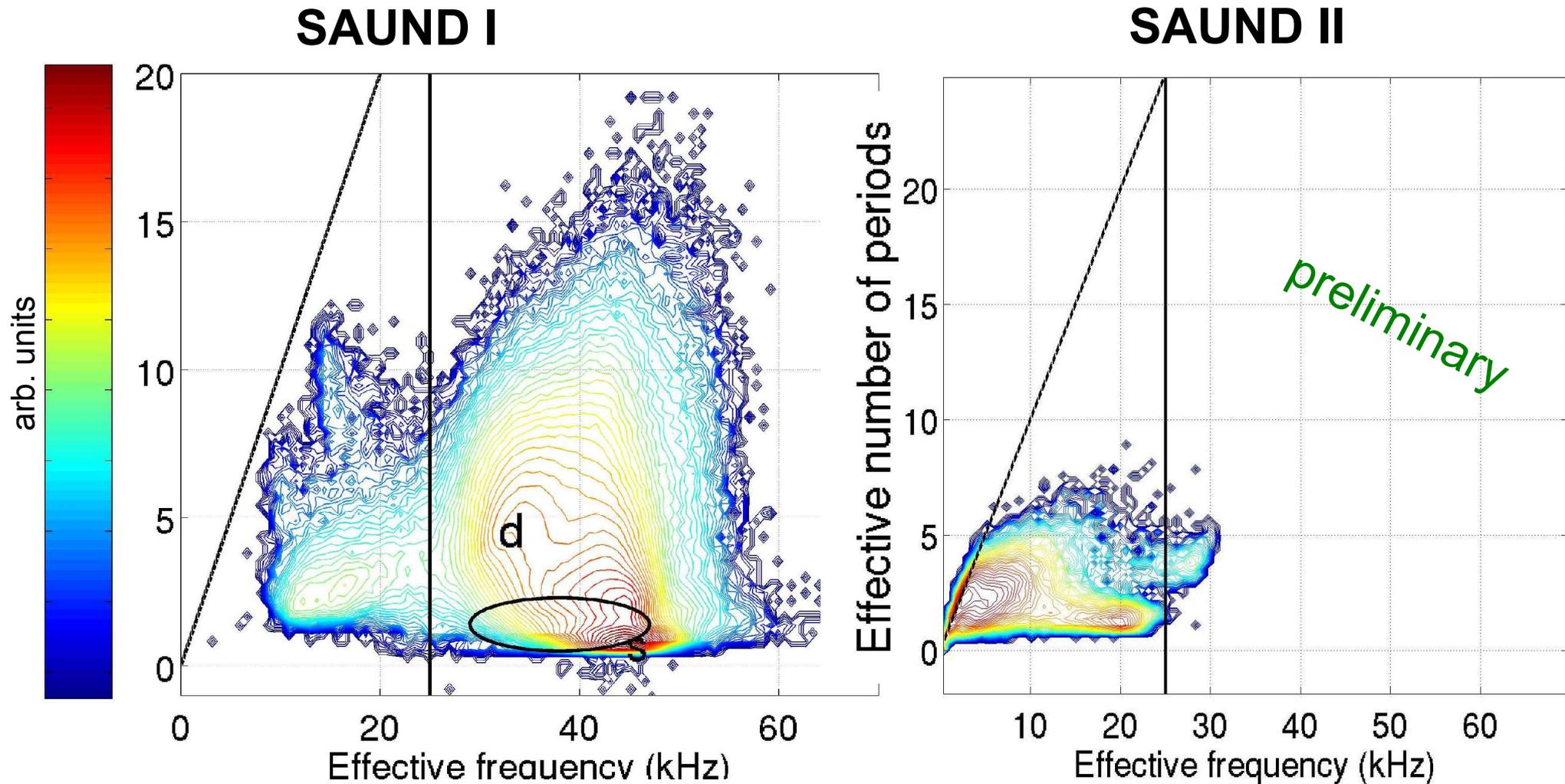
A “diamond” event  
(a marine mammal  
clicking?)

Depending on noise  
conditions, we get many  
types of “false” triggers



Almost looks like a neutrino  
signal, but very suspicious.  
Could be mammal? Could be  
electronic noise?

# Trigger Identification



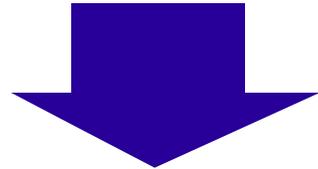
(height normalization is not the same)

# Summary

0. First installation complete. Currently taking data on 14 channels!
1. The new AHRP system gives us improved system conditions
2. We have developed the capability to process the full array of 60 hydrophones spanning over 1000km<sup>2</sup> of ocean floor (scheduled installation August 2005)
3. Our initial data show consistency with SAUND I with improved noise condition
4. Precise calibration tool is in R&D stage, expected to be ready by this winter (prototype deployment scheduled August 2005)

# SAUND II Schedule

- March 2005: Installation of 14 channels across multiple computers  
*✓ done!*
- ✓ done!* Lightbulb calibration
- August 2005: Installation of all computers for full array readout  
  
Zapper prototype deployment
- Early 2006: Full zapper calibration  
Final DAQ software tweak



~ 2yrs of steady data taking  
Full Analysis

