Radio Čerenkov measurements in salt

UH Salt Detector Testbed

P. Miočinović

University of Hawaii at Manoa, Honolulu, Hawaii, USA

ARENA Workshop, DESY Zeuthen

May 19, 2005

Outline

- Motivation

- Experimental setup

- Analysis progress

- Summary and Outlook

Motivation

- Detecting the first coherent radio Čerenkov signal of natural origin

- Exploration of Askaryan effect in rock salt in broad range of energies

- Evaluating potential of rock salt as a medium for detection of UHE particles

- Electronics evaluation testbed for ANITA and SalSA

Experiment

- **Target material: 20 tons of synthetic rock salt**

    - rock salt blocks, weighing 22.7 kg each

    - purity of the salt: 93-96%

- Bowtie antennas embedded in salt and amplified by cable TV technology
- Computer controlled waveform readout
- Camac-based trigger from MACRO particle counters; 100 GeV threshold, ~2500 ev/day
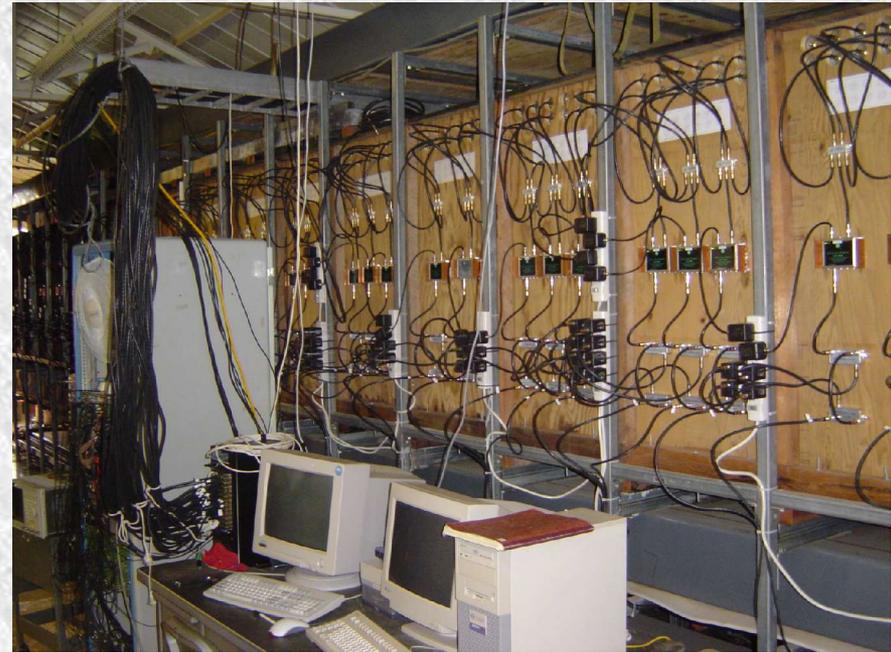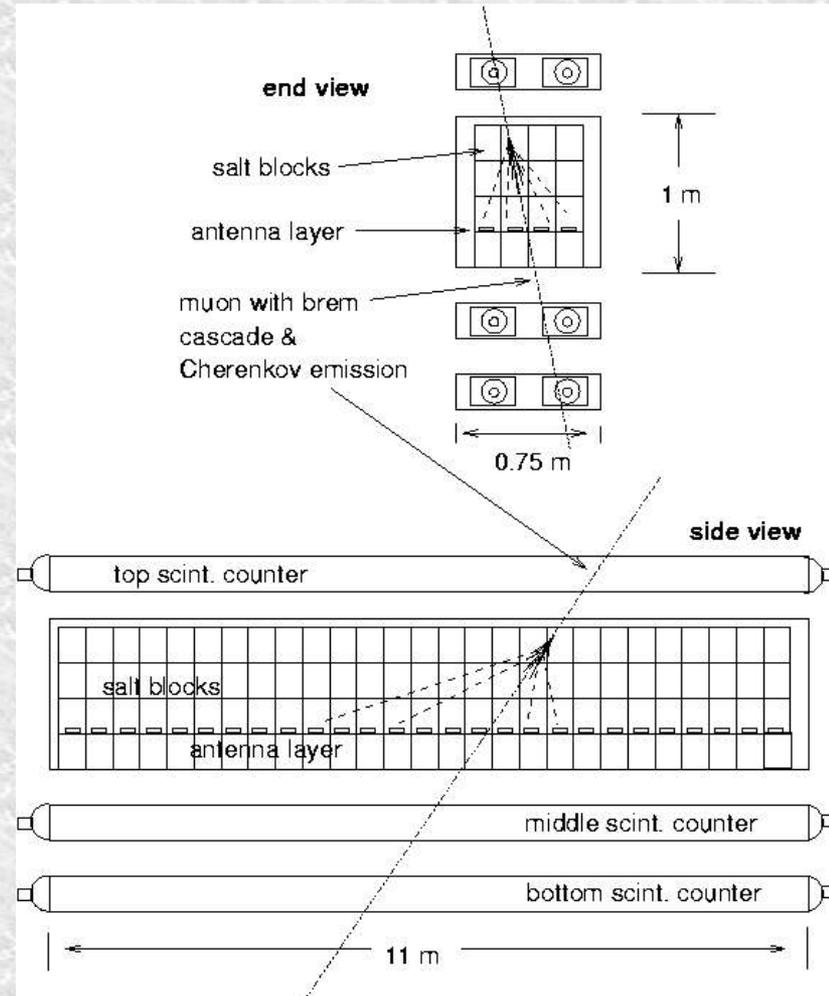
Experimental Setup

- 20,000 kg of synthetic rock-salt placed in the rectangular wooden box.

    - index of refraction n = 2.4; θ_C = 65°

    - specific density ρ = 2.08 g/cm^3

    - radiation length Xo = 13.5 cm

    - critical energy E_C = 52.6 MeV

- dimensions of the box 12 x 1.2 x 0.8 m
- interior walls covered with thin zinc plated steel sheets
- two rows of antennas were placed on the lowest layer of salt blocks.
- 3 MACRO counters track charged particles as a trigger for antenna readout.

end view

salt blocks

antenna layer

1 m

muon with brem cascade & Cherenkov emission

0.75 m

side view

top scint. counter

salt blocks

antenna layer

middle scint. counter

bottom scint. counter

11 m

Antennas and RF readout

- Dual linear polarized bowtie antenna printed on PCB
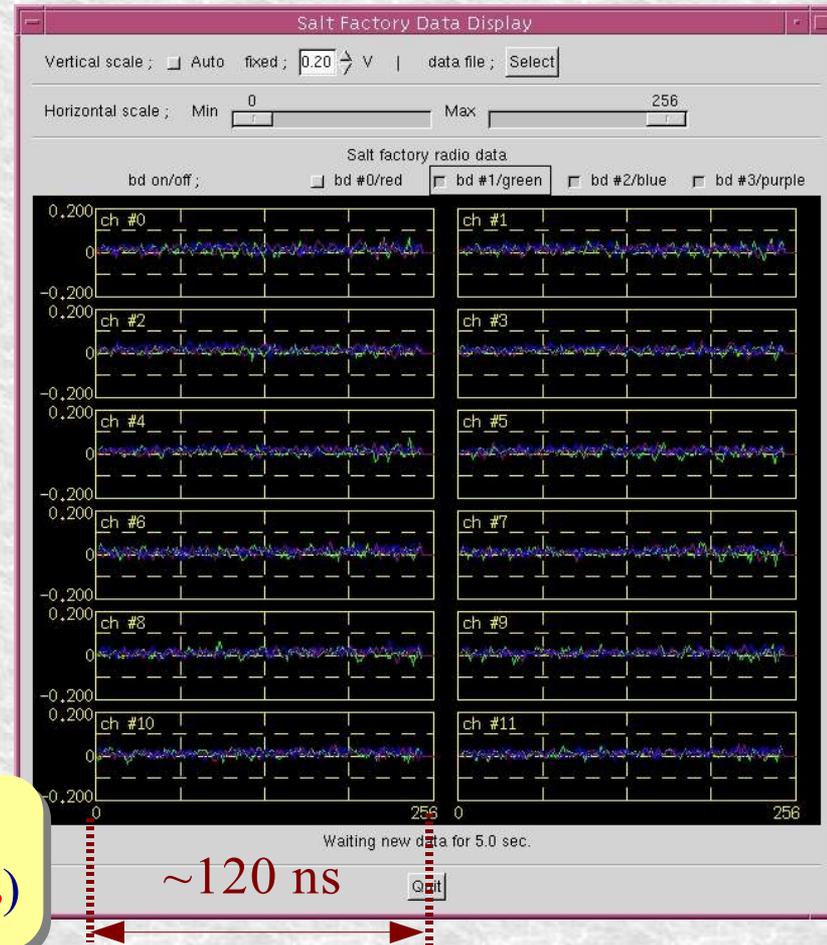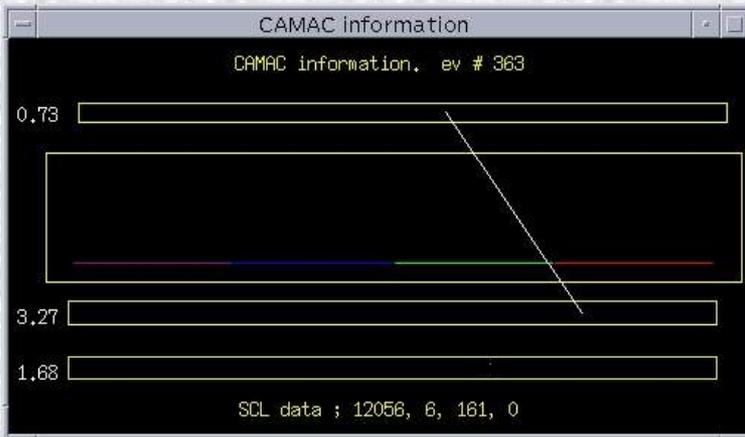- Frequency response ~0.2-2.0 GHz

300 MHz

600 MHz

920 MHz
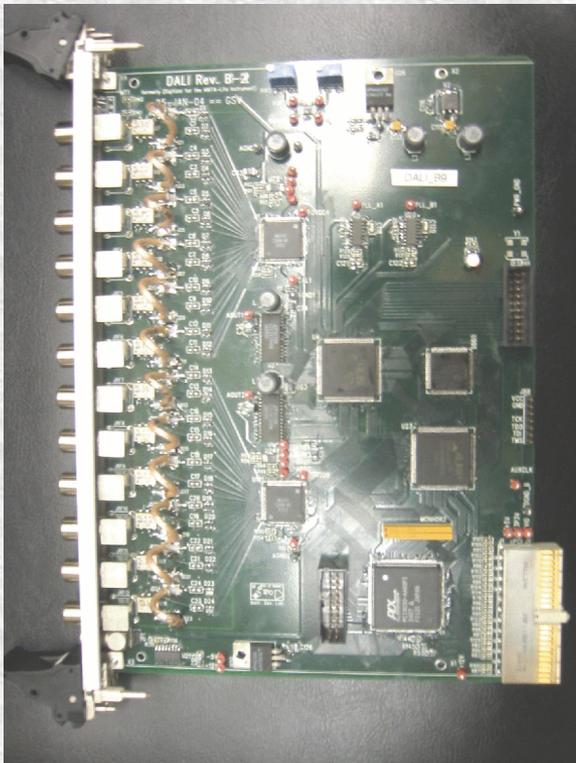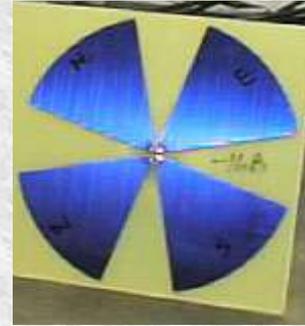
- RF readout through a custom, low-power digitizer chip (STRAW2) mounted on cPCI card (ANITA/SalSA prototype)
- 12 RF channels per card
- sampling rate 2.12 GS/sec, ~250 samples per waveform
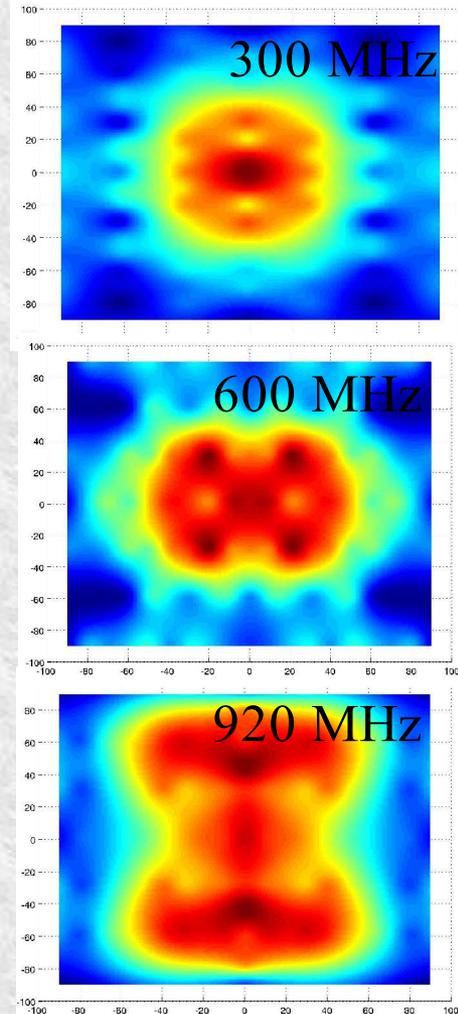
Data Taking

- For each trigger, 48 RF signal and 12 PMT signal channels are readout

- Two dimensional reconstruction of particle track is based on PMT timing

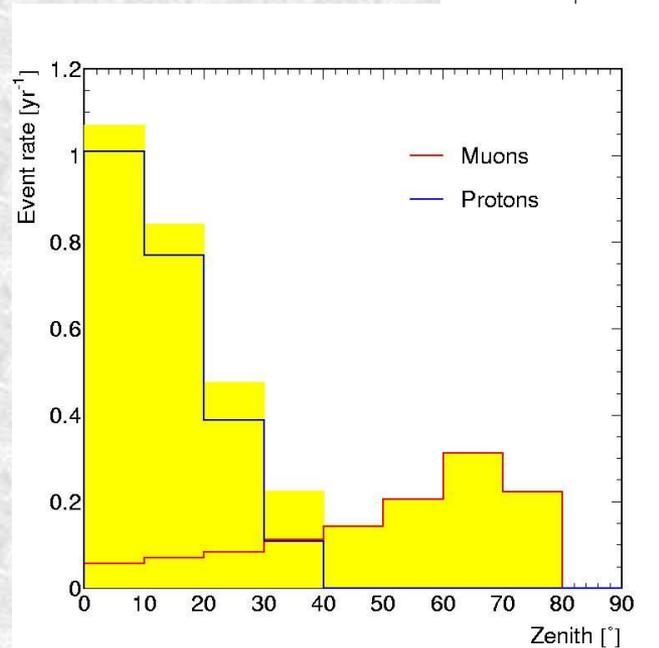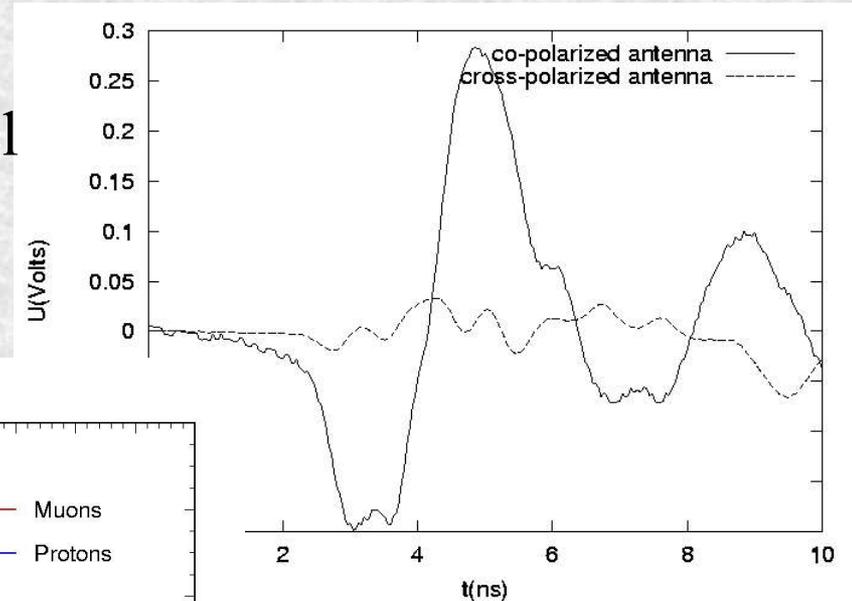- 2.7 sec later, background RF reading is taken

fully captured particle transit window (~ 60 ns)

~120 ns

MC expectations

– based on Askaryan signal strength measured at SLAC, 1σ voltage level for cascade energy of 2.8 TeV

– Total expected event rate is 3.45 events/yr

– 2σ rate 0.86 ev/yr

Analysis

RF data filtering:

- need to digitally filter out RFI; 50-95 MHz and 200-260 MHz bands due to local FM (college radio station next door) and UHF TV stations

Strategy I:

- build matched filter based on SLAC measurements of bowtie response to Askaryan pulse + lab measured system response
- scan all events for coincident pulses consistent with the expected shape
- analyzed 2 months of data, but no clear candidates yet
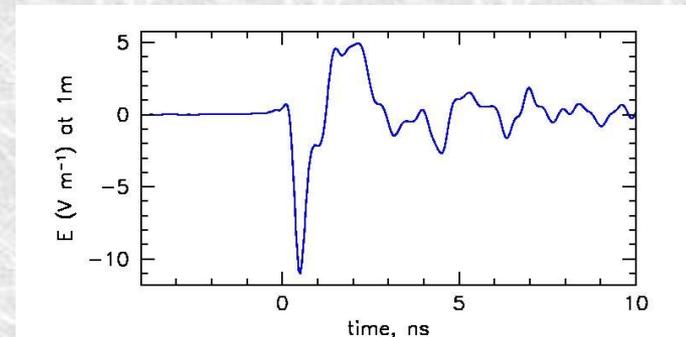
Bowtie response to Askaryan pulse

Analysis, cont.

Strategy II:

- To improve our sensitivity, coherently add RF data; i.e. add sub-threshold events in order to boost SNR

- Look for a statistical increase in RF power seen by antennas during triggered events compared to background RF events

- So far, analyzed 1 month of data and we have no statistically meaningful result, yet. Better event selection required.
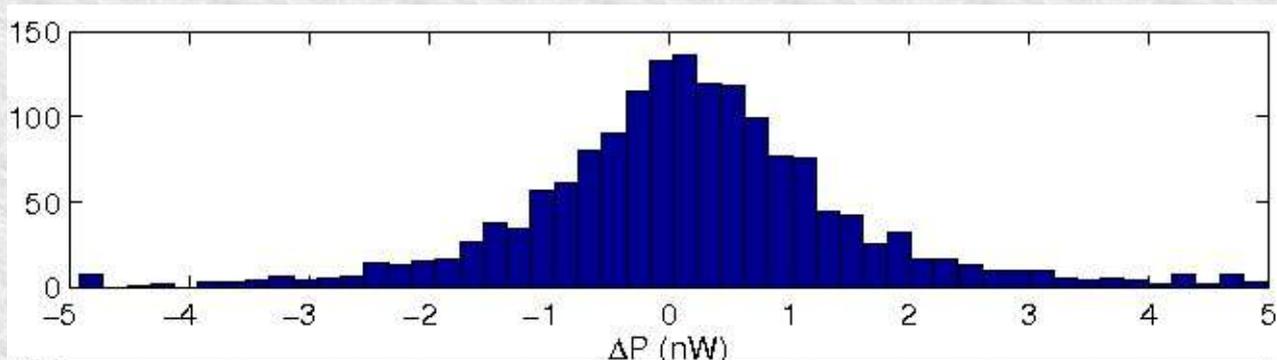
Summary

- The testbed experiment is looking for Askaryan radio pulses induced by cosmic ray secondaries

- Built on a shoestring budget ($40-50k), but proving to be essential for hardware development platform for both ANITA and SalSA

- Motivated by a good physics goal, not just a technology testbed

Outlook

- Data rates are limited by:
  - **RF noise**
    - custom low noise amplifiers
    - better RF readout with new digitizing chips and cards
    - place experiment further away from RF noise pollution
  - **Atmospheric depth**
    - move to higher ground for increased particle flux
  - **Size, size, and size**
    - Increase the volume of instrumented salt