Simulation Chain for Acoustic UHE Neutrino Detectors

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Friedrich-Alexander-Universität
Erlangen-Nürnberg

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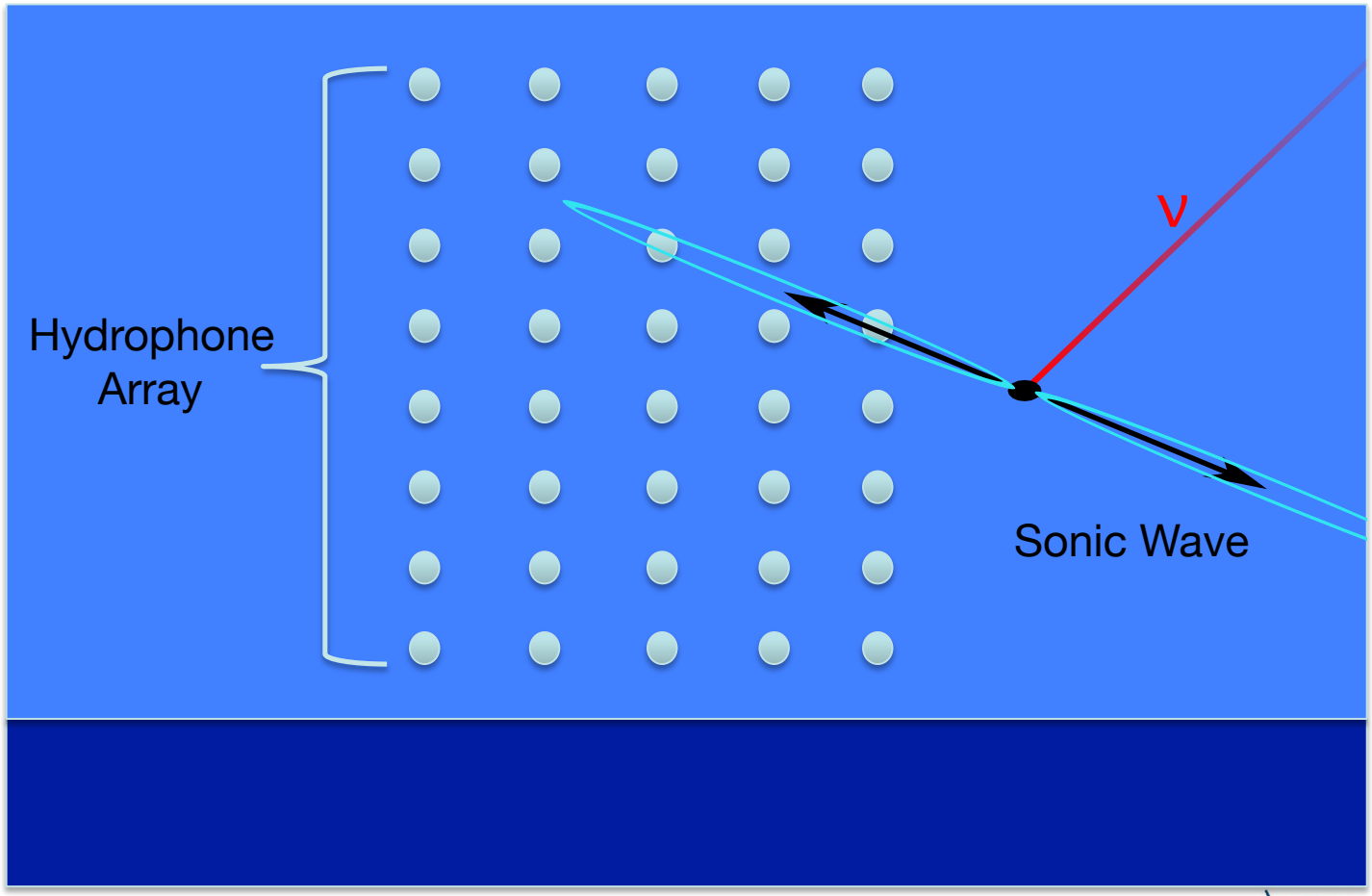
Acoustic Detection Principle



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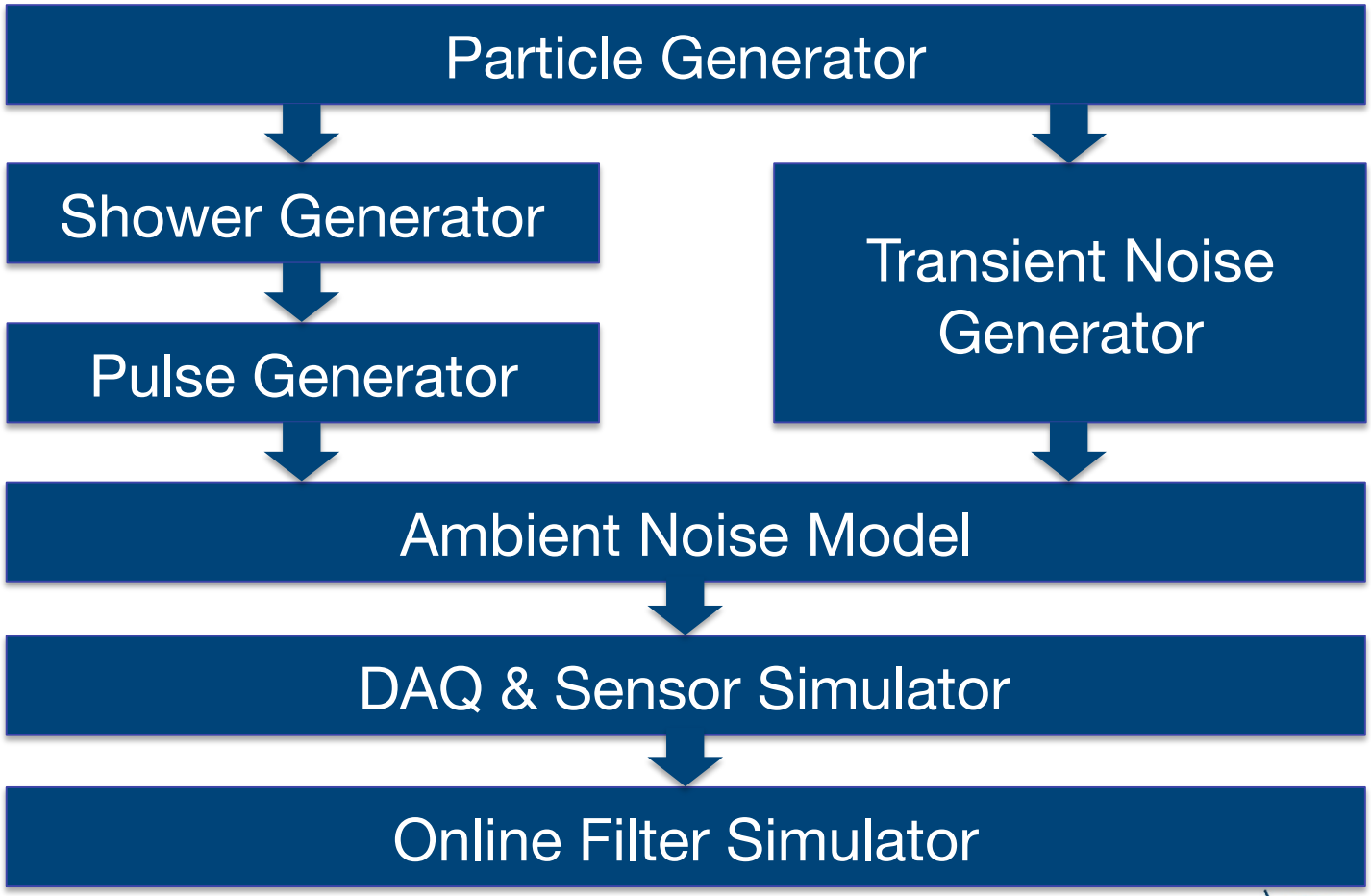
Some Facts

- Simulation chain integrated in the SeaTray framework
- Modular, easy to adapt (detector geometry & media, hardware)
- This presentation focuses on:
  - Water as detection medium (Mediterranean Sea)
  - Hydrophones as sensors

Simulation Chain Modules



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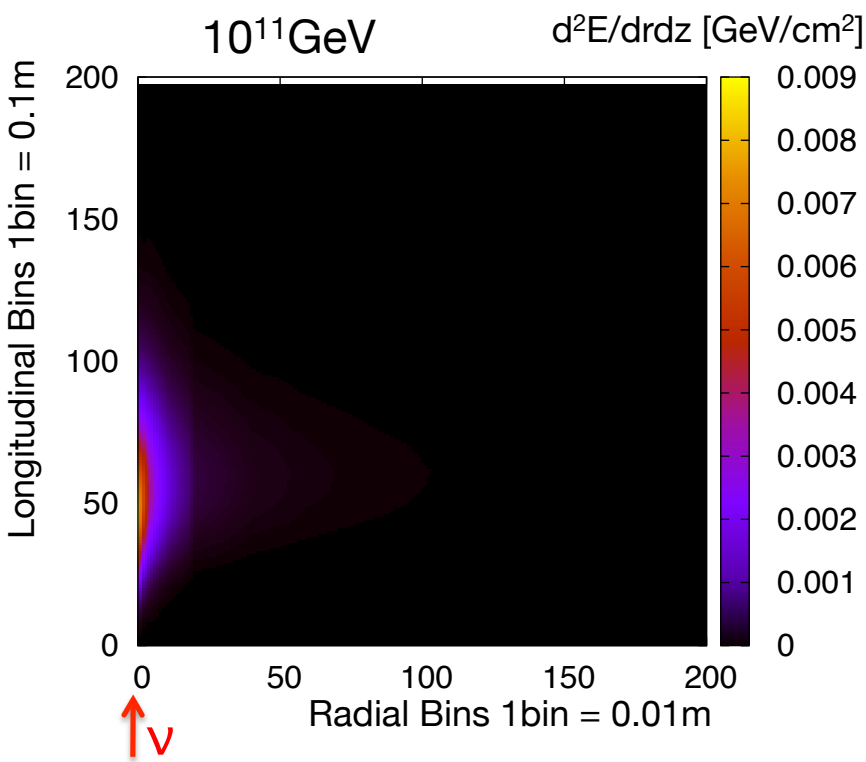
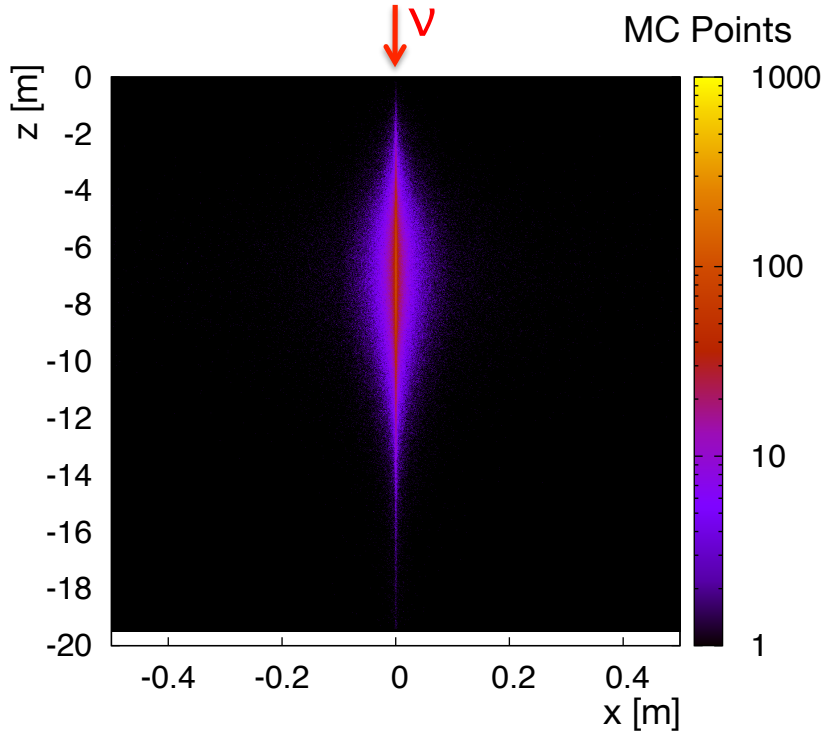
Shower Generation





Shower parameterization
Distribution of deposited energy
(Acorne Coll., arXiv:0903.0949v2)

Points produced with density proportional to the deposited energy density

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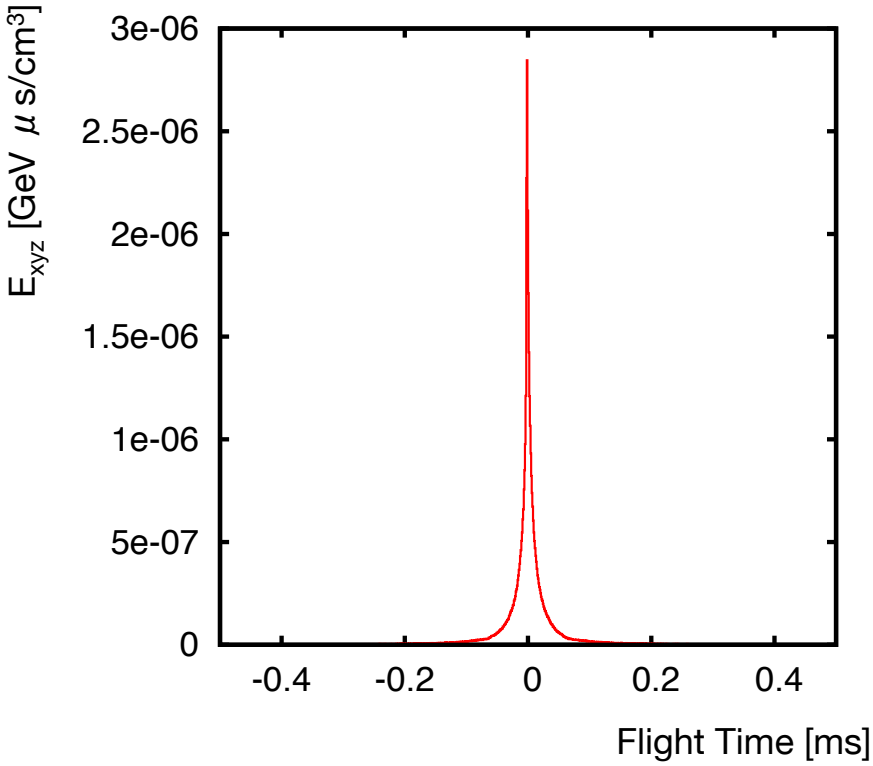
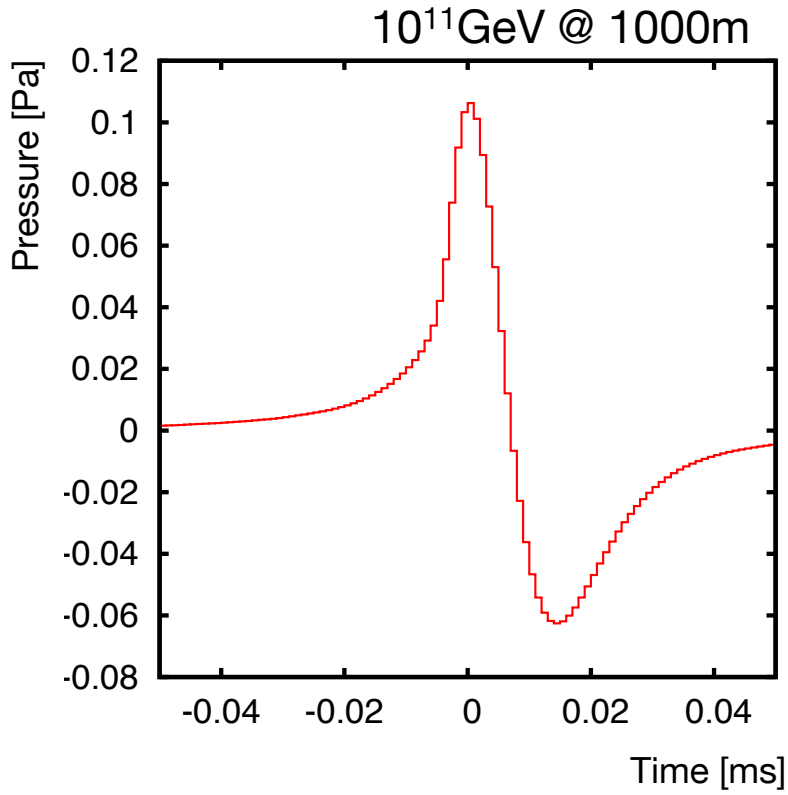
Pressure Pulse – Generation





Histogram of the flight time to the sensors, scaled with bin-width (1 μ s) ➔ $E_{xyz}(t)$

d/dt E_{xyz} + attenuation results in pressure pulse at the sensor

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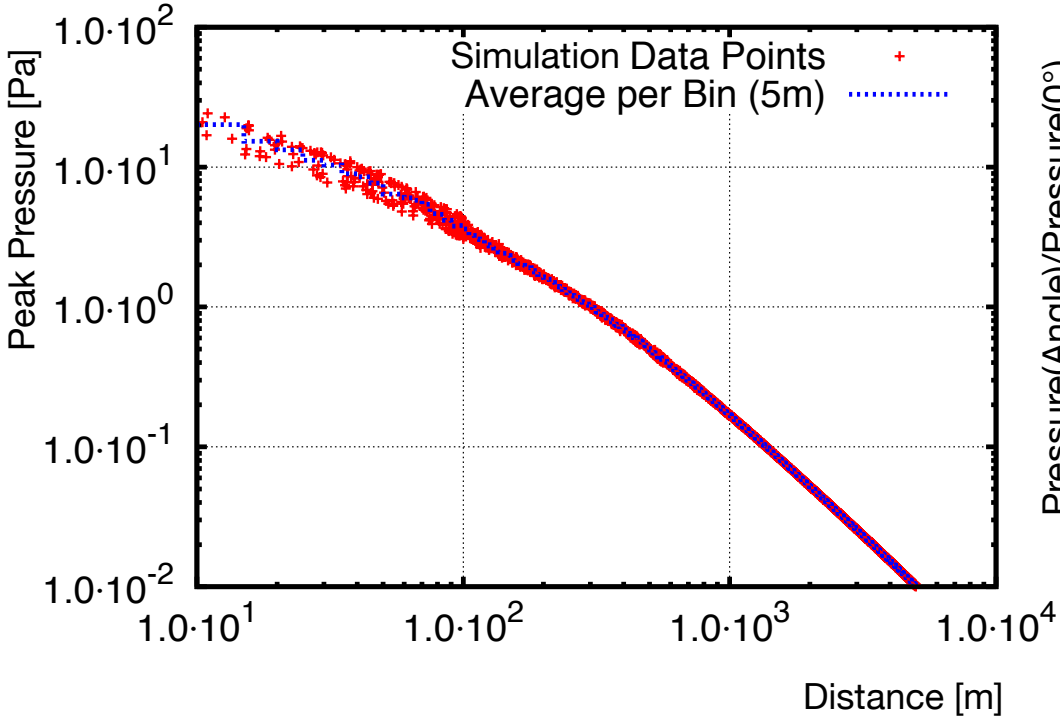
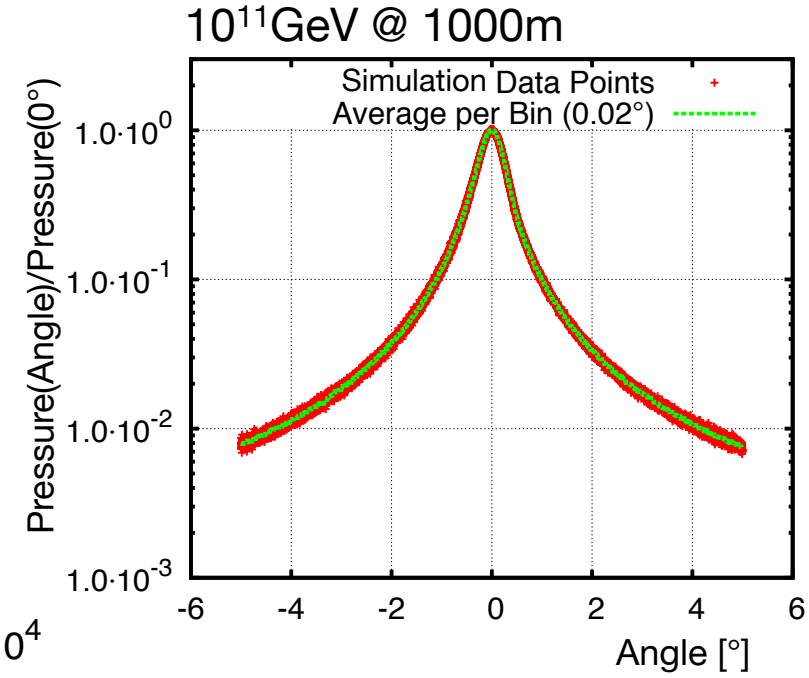
Pressure Pulse – Amplitude Dependencies



Dominated by geometric spreading: 1/r



Peaked emission perpendicular to shower axis ➔ “Pancake”

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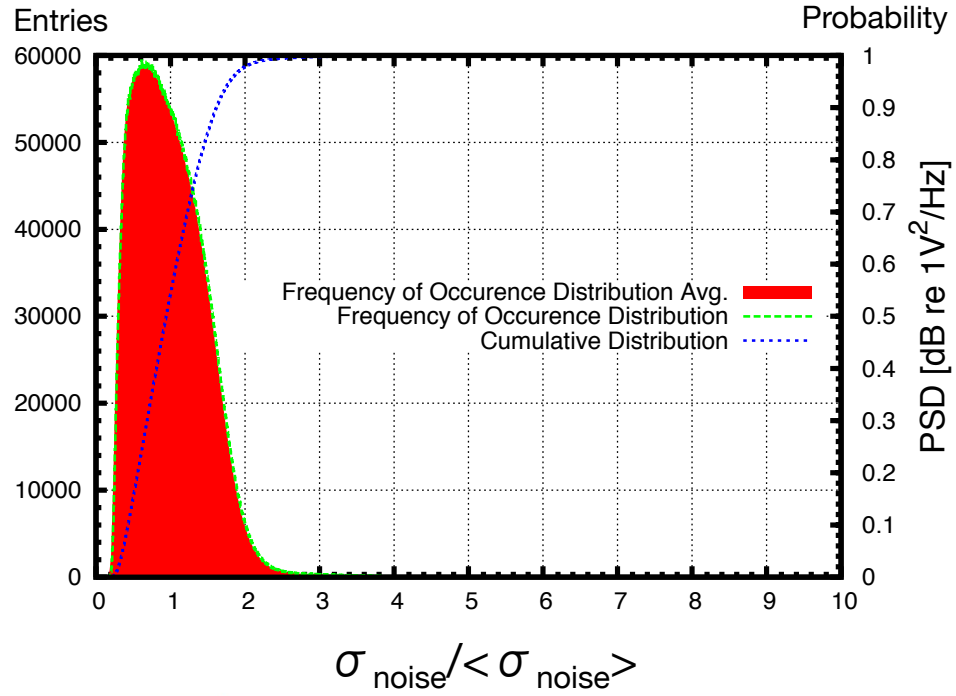
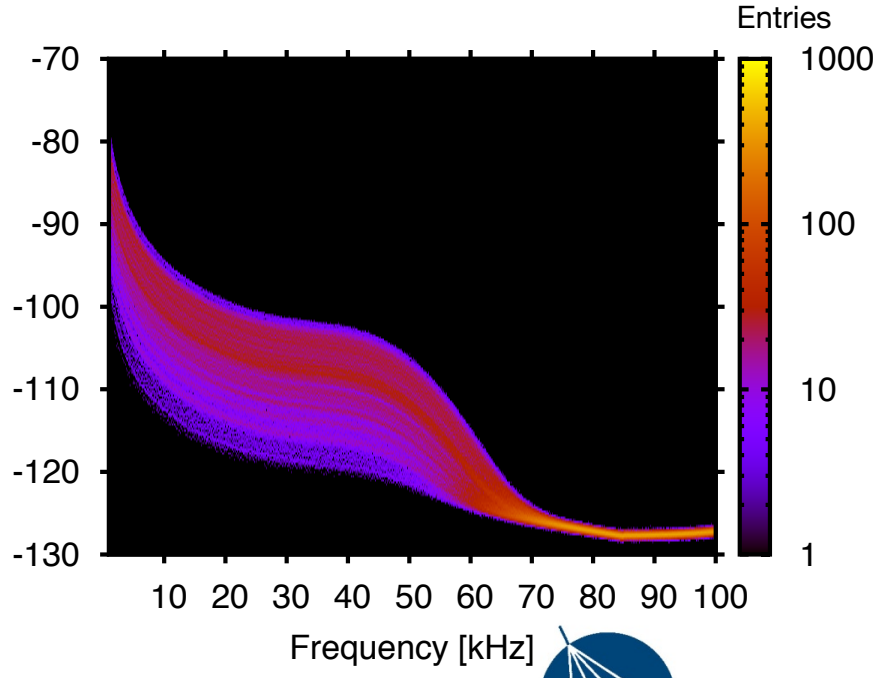
Ambient Noise Model

- Realistic deep-sea ambient noise model
- Knudson curves + attenuation
- $<\sigma_{noise}>$ is ~10 mPa; 95% of the time $\leq 2<\sigma_{noise}>$





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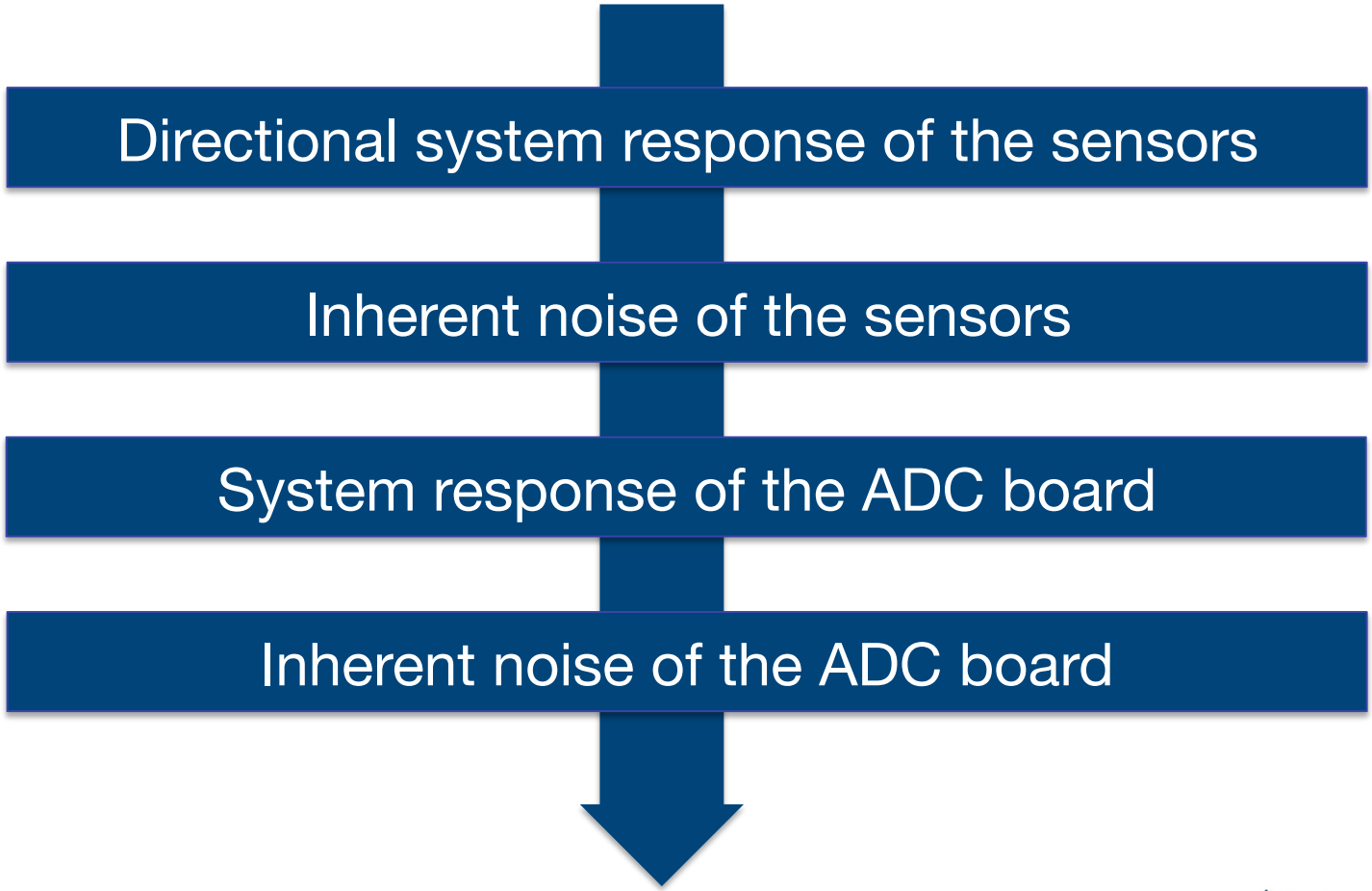
DAQ & Sensor Simulation



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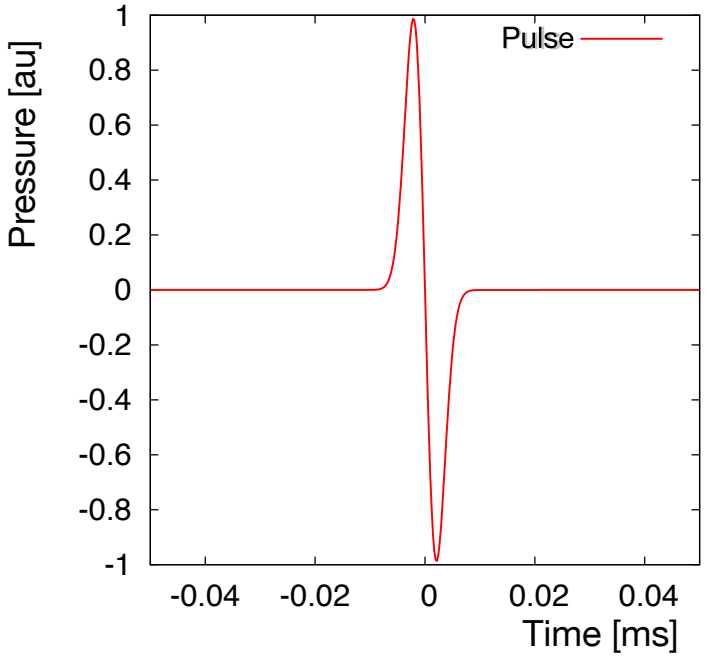
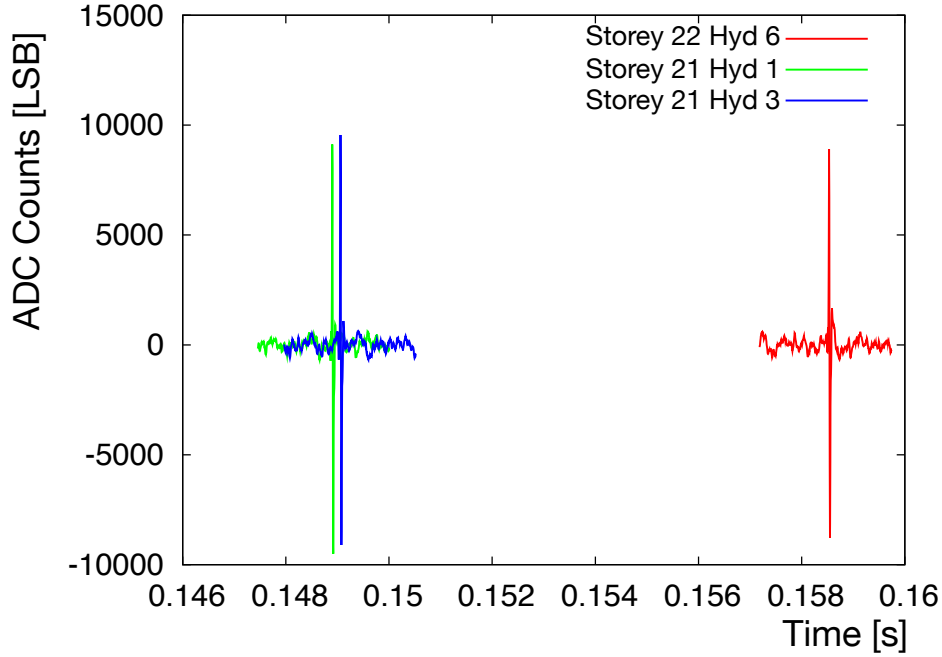
Online Filter Simulation

- Online Filter ➔ pre-selection & data reduction
- Matched filter + coincidence test





Used as reference signal

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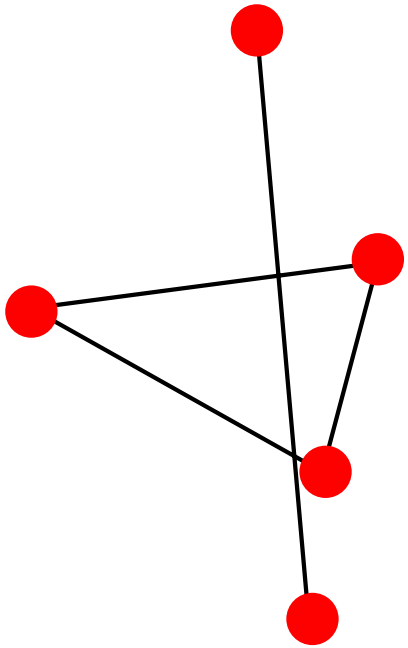
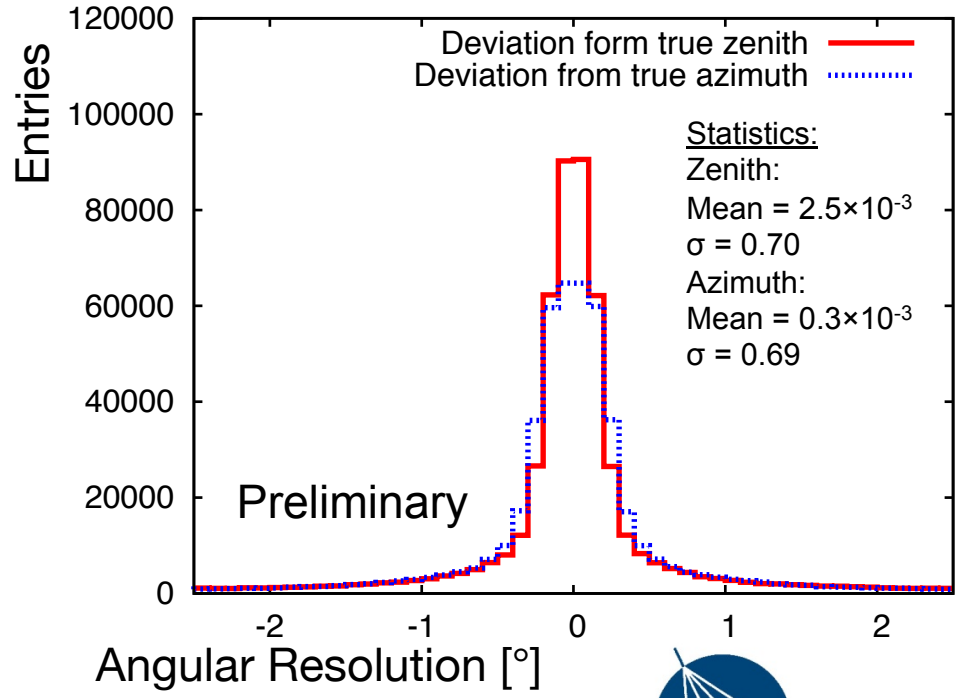
Direction Reconstruction

- Determination of arrival time crucial for reconstruction
- Timing resolution of about 1μs
- Least square fit: $min\left(\sum_i \left(t_{i_M} - t_{i_E}(\theta, \phi)\right)^2\right)$



Generic acoustic storey



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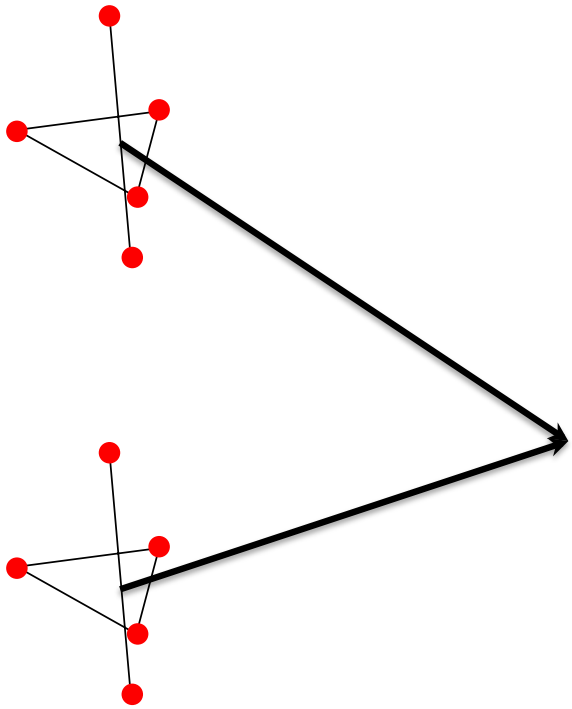
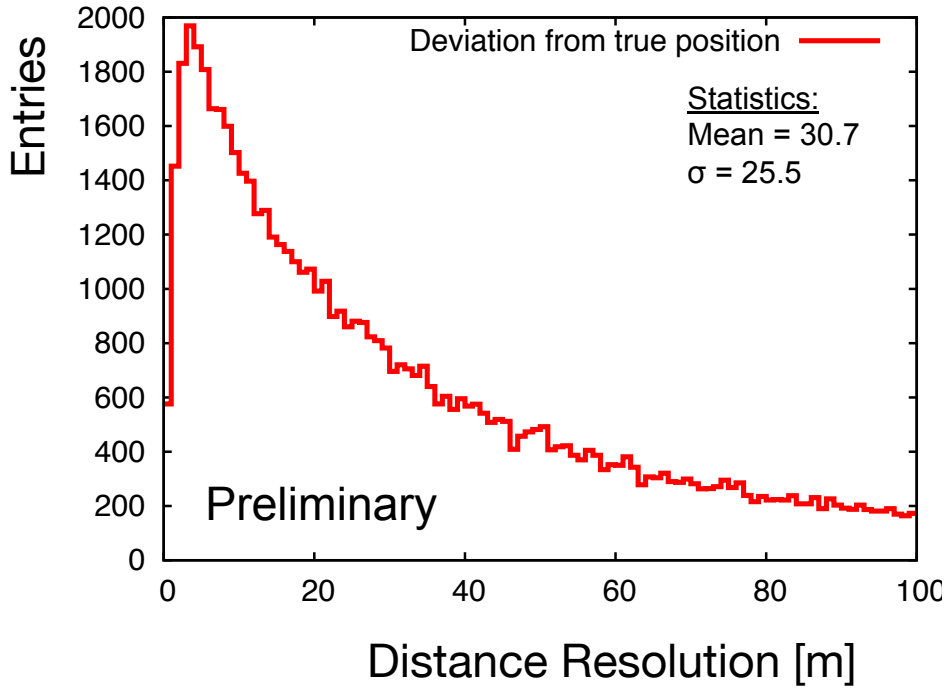
Position Reconstruction

Triangulation using previous direction reconstruction





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Signal Classification

- Different machine learning algorithms have been investigated:
  - Naïve Bayes
  - Decision Tree
  - Random Forest
  - Boosting Trees

  } Best performance, fast and robust

  - Support Vector Machine
- Either extracted features or the triggered waveform as input
- Individual sensors: Recognition error $< 10\%$
- Clusters of sensors: Recognition error $< 2\%$

Summary and Outlook

- Implementation of the simulation almost completed – refraction missing feature
- Simulation reproduce the system and conditions
- Analysis software almost completed
- Detailed studies for effective volume, trigger efficiency, signal classification will follow

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