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# A GPU Sonar Simulator for Automatic Target Recognition

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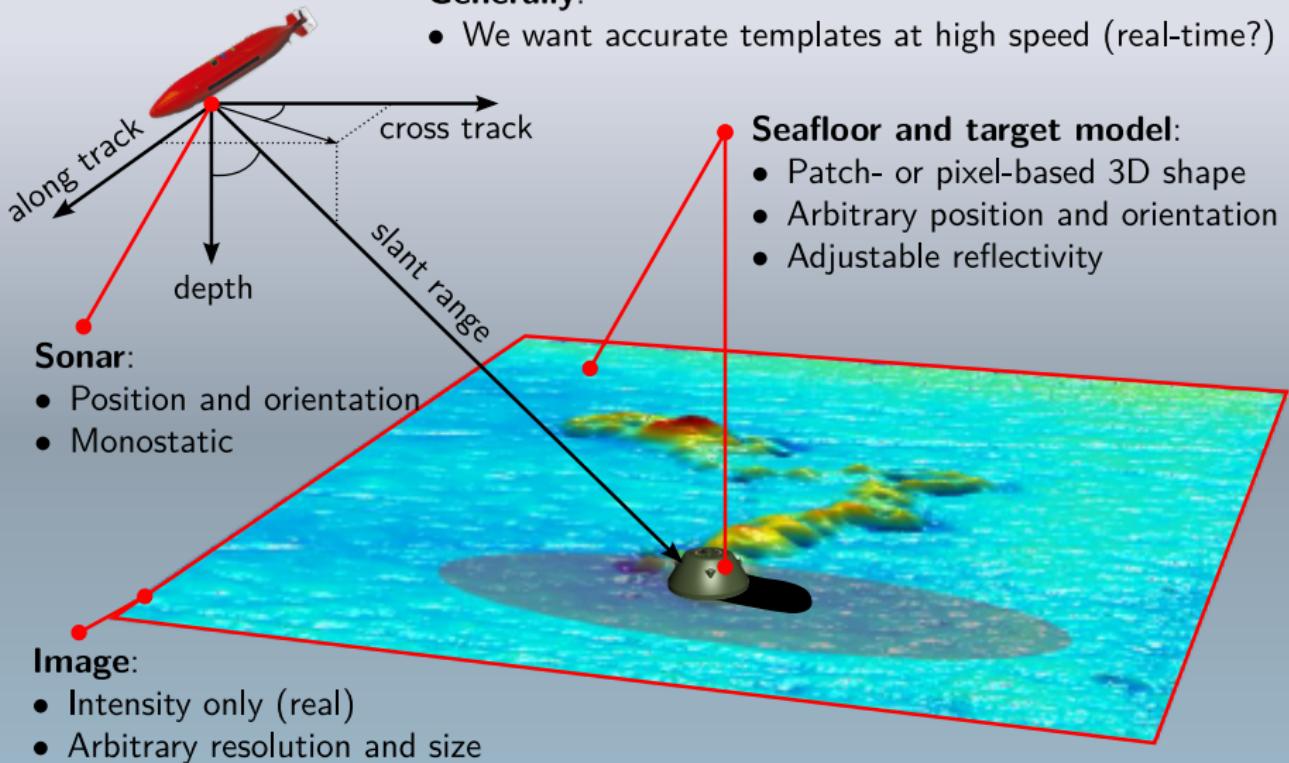


Rhodes, Greece, 2014

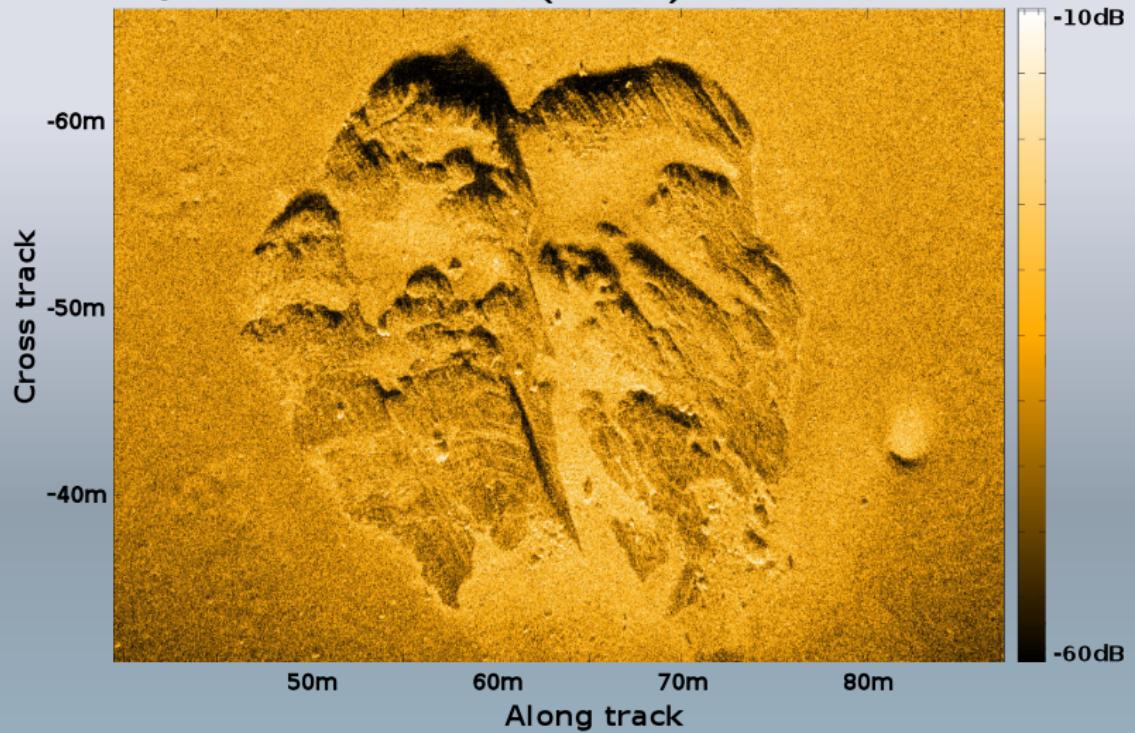
# Simulator features

Generally:

- We want accurate templates at high speed (real-time?)



# Synthetic Aperture Sonar (SAS)



- ▶ SAS image of a  $25 \times 25$ m wide by 5m high rock formation at 70m depth.
- ▶ Theoretical resolution of 3-4cm throughout the image.
- ▶ Data from the HUGIN AUV carrying the HISAS1030 interferometric SAS.

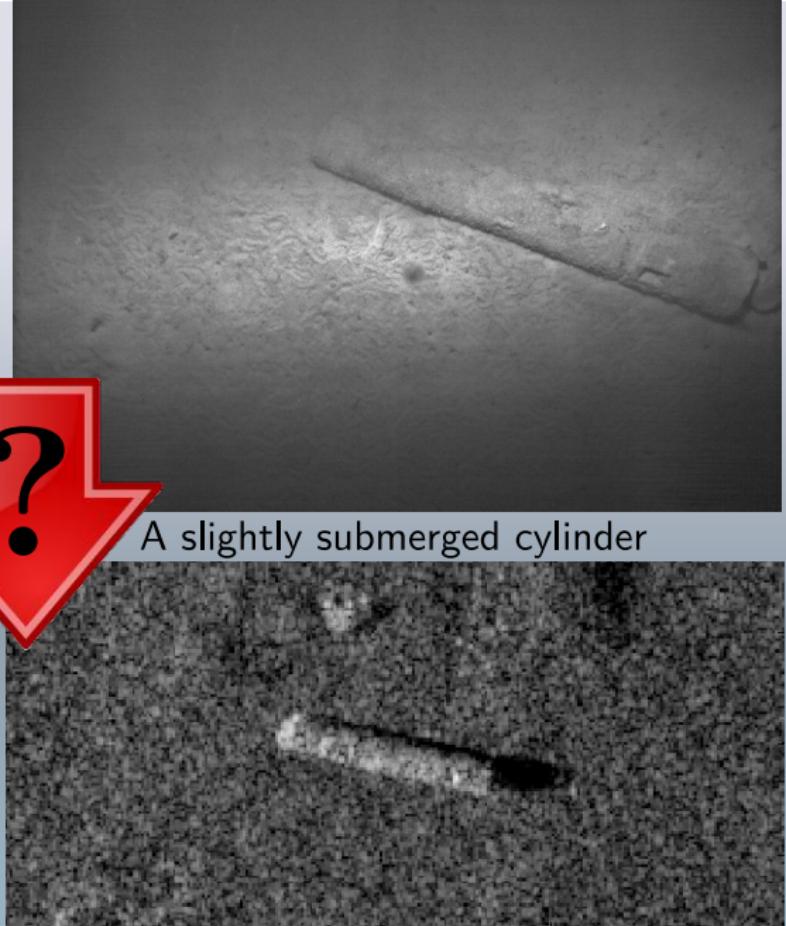
# SAS vs optics

## Similarities:

- High resolution
- Scattering mostly determined by inclination angle
- ?



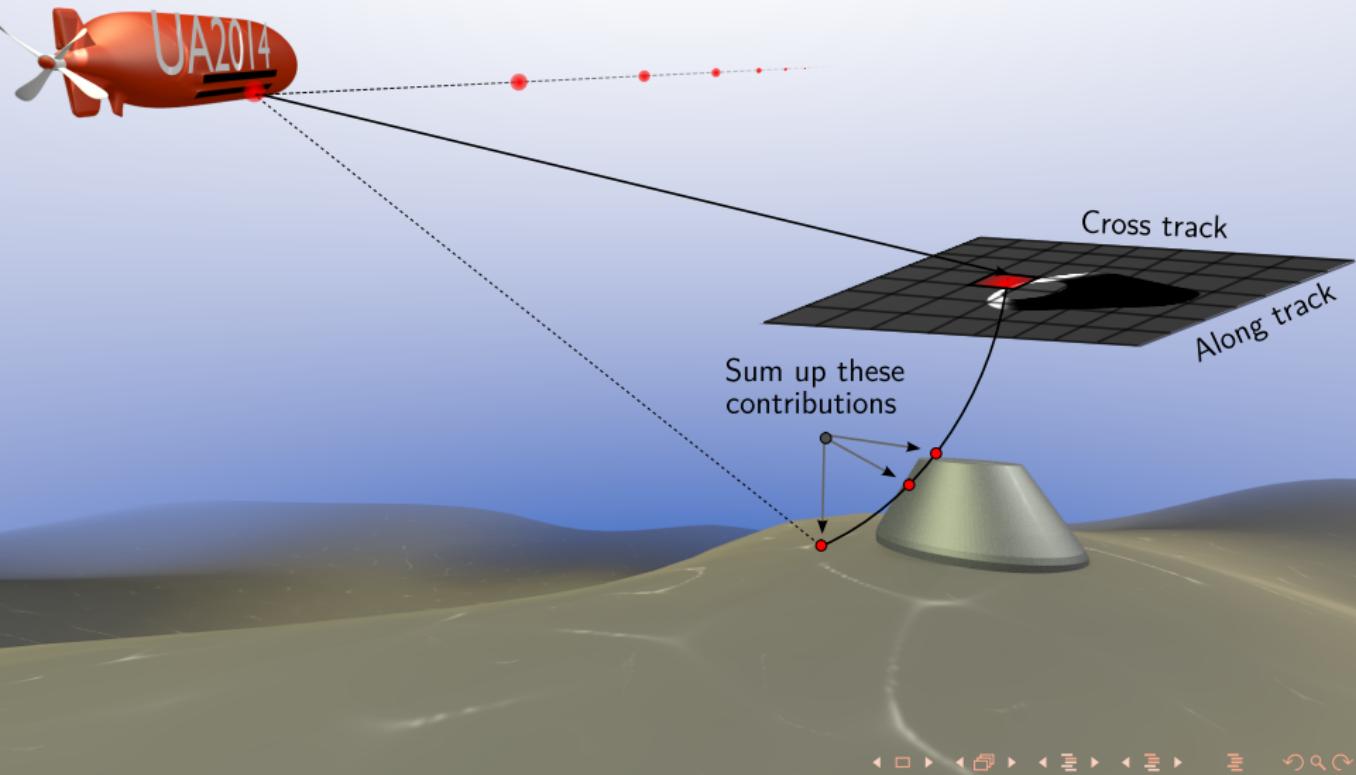
A slightly submerged cylinder



SAS image at range 73m

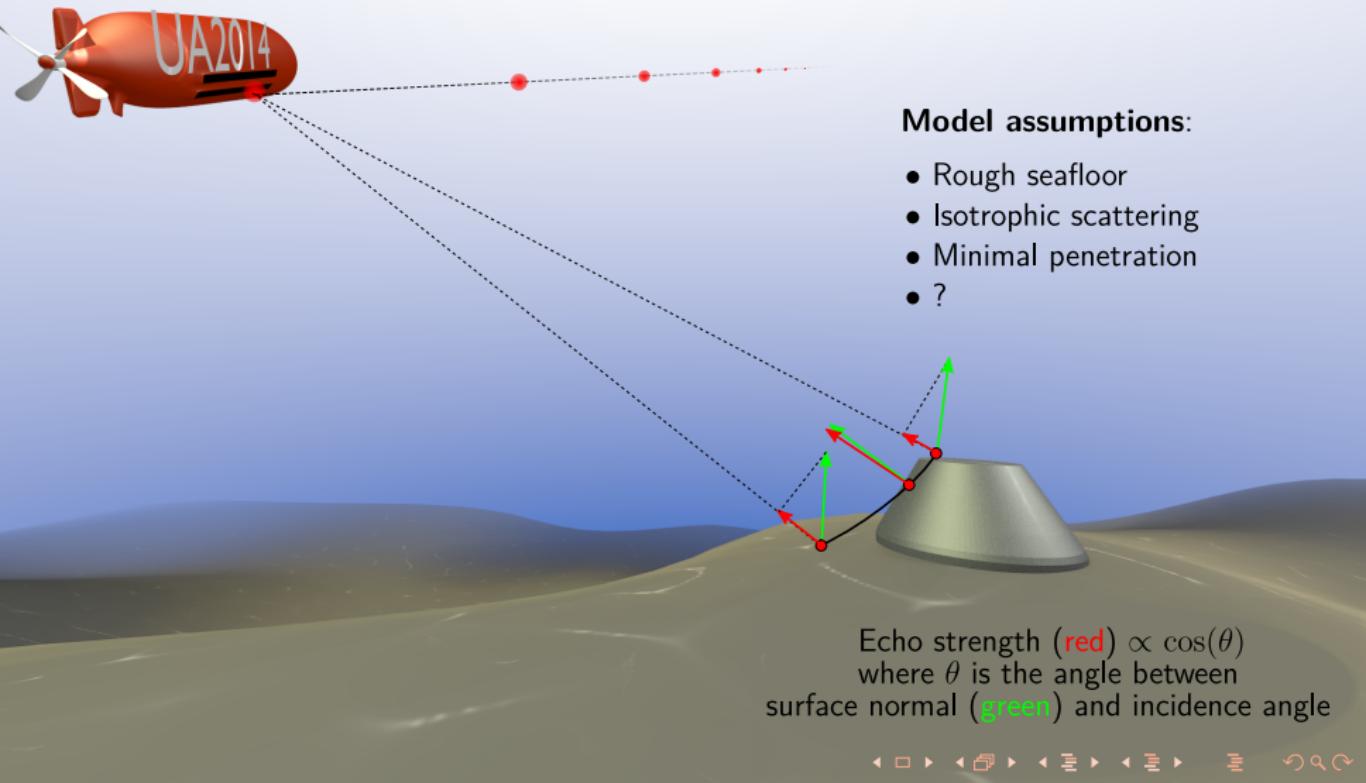
# Simulating a ranged sonar

Simple when only considering direct scatter



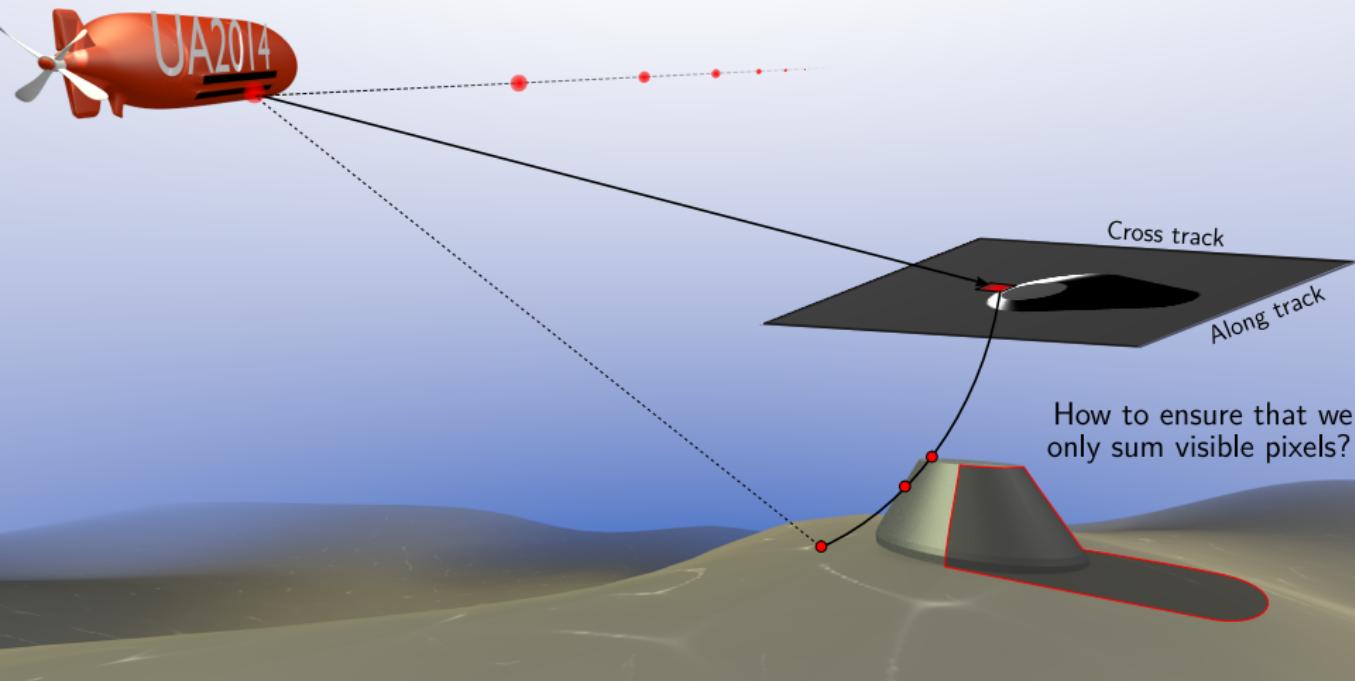
# Simulating a ranged sonar

Scattering strength given by Lambert's law



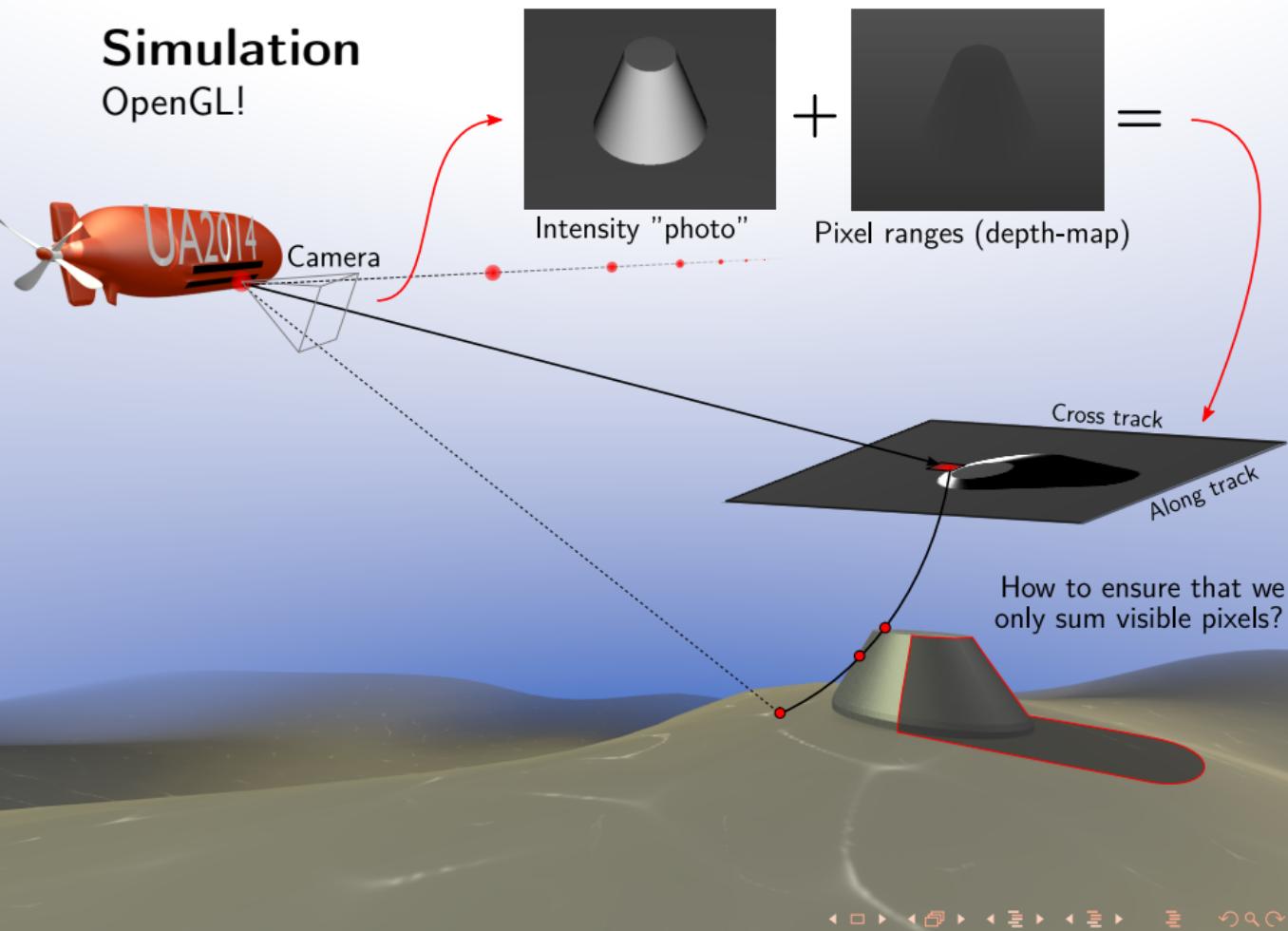
# Simulating a ranged sonar

How to deal with “hidden pixels”?



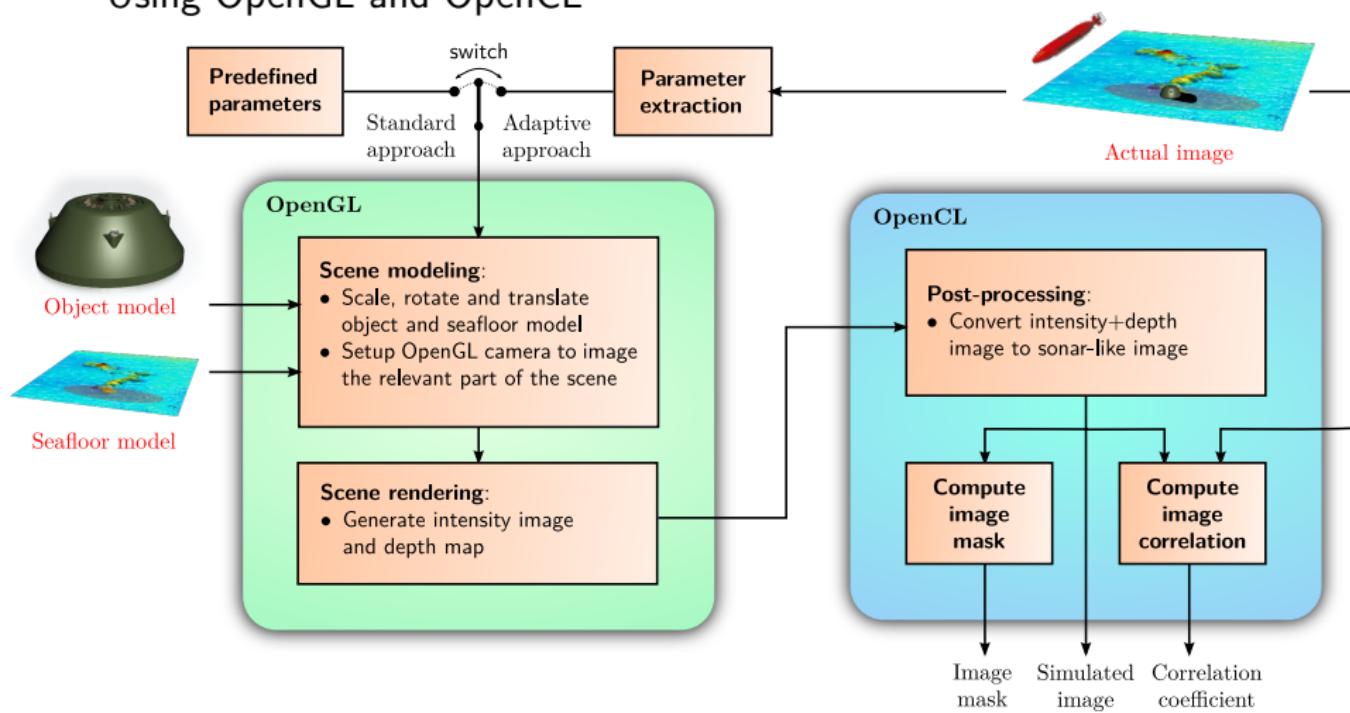
# Simulation

OpenGL!



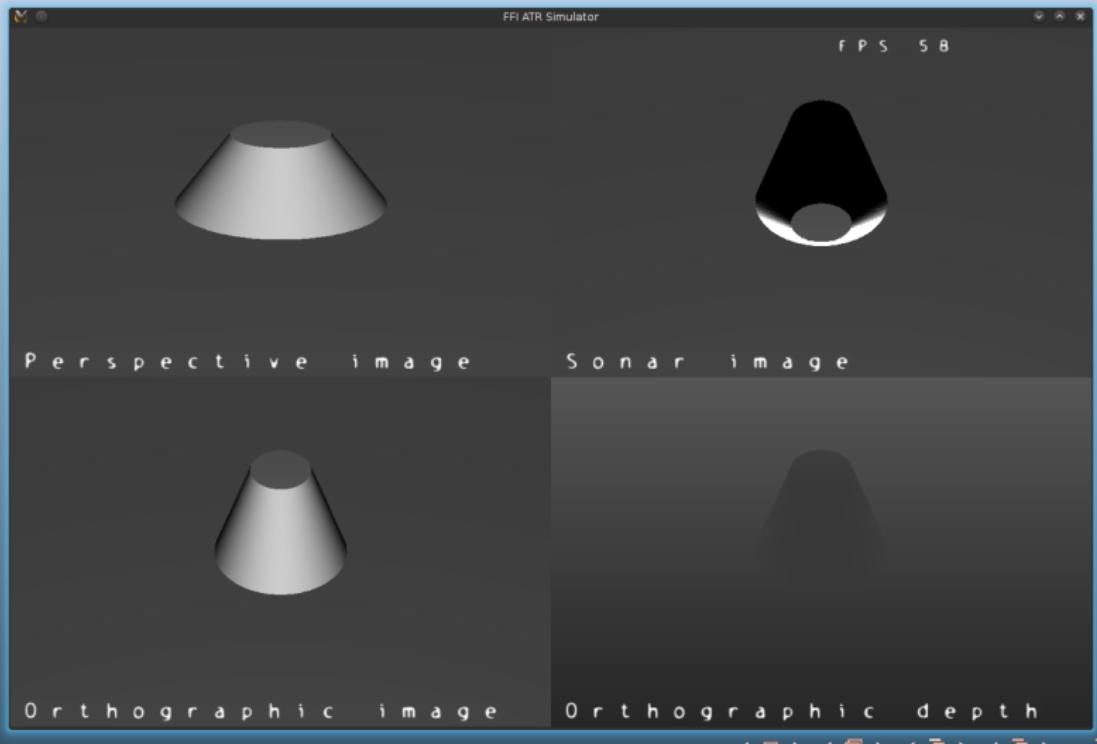
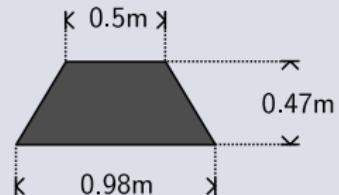
# Implementation

## Using OpenGL and OpenCL



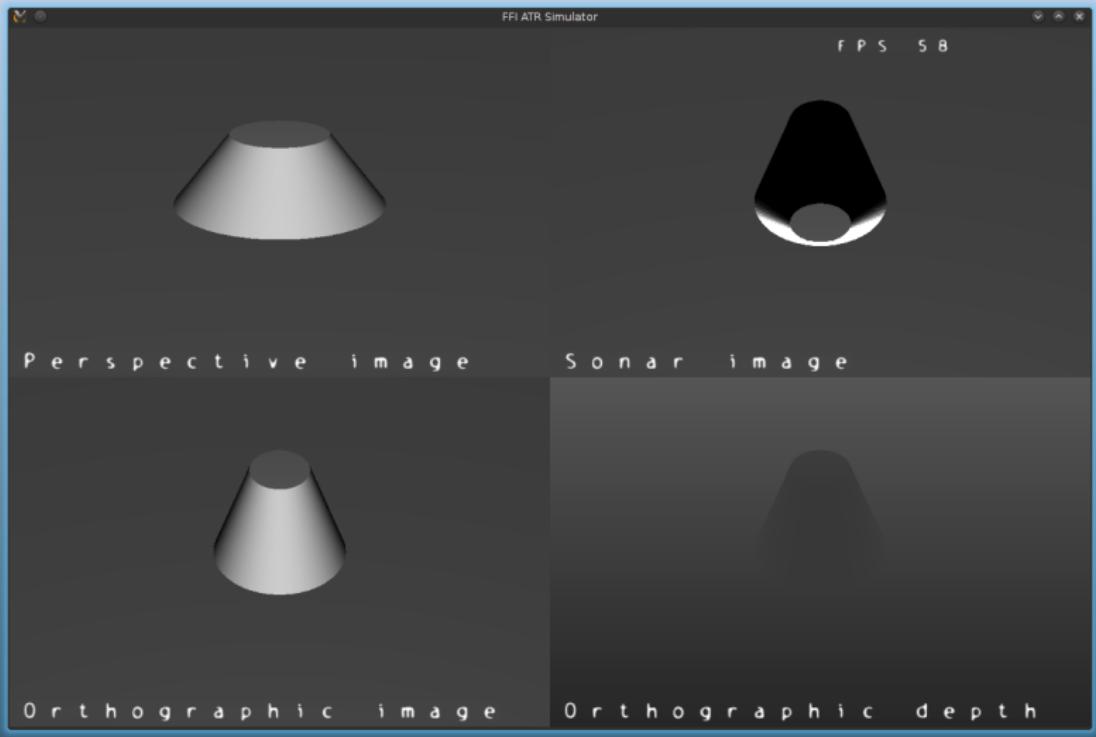
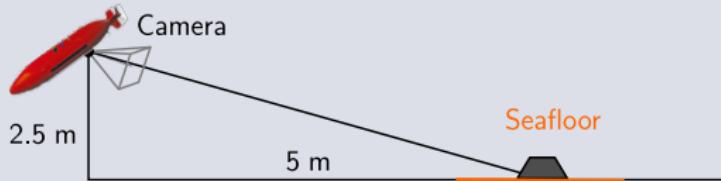
# Results

Looking at the viewer



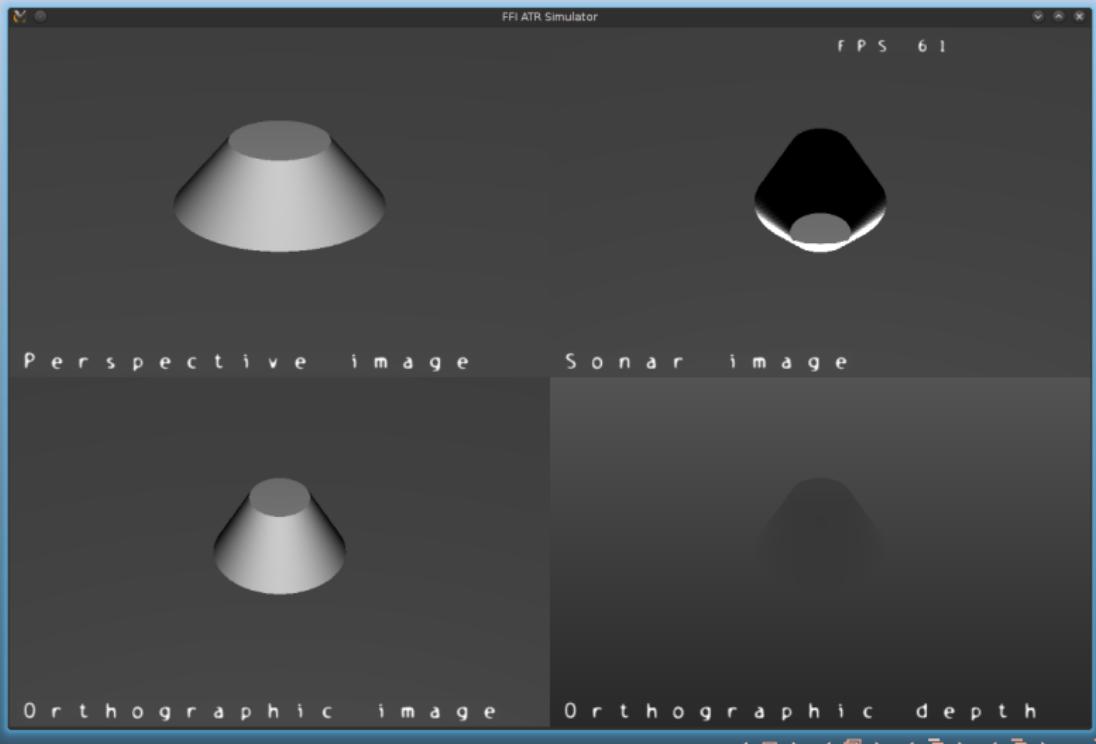
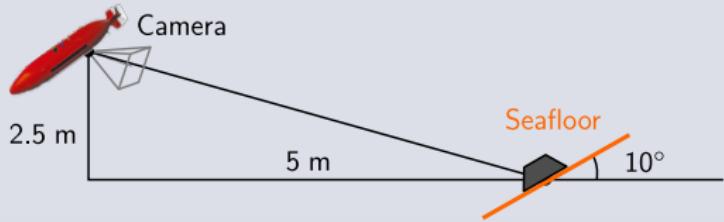
# Results

Looking at the viewer



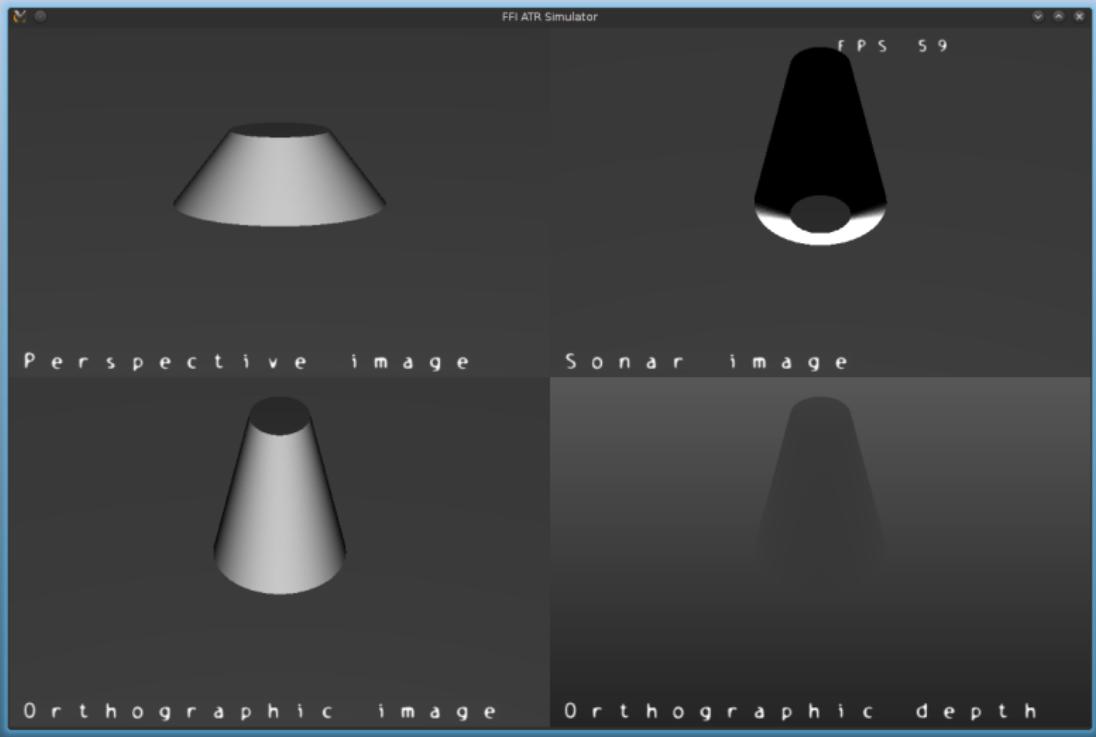
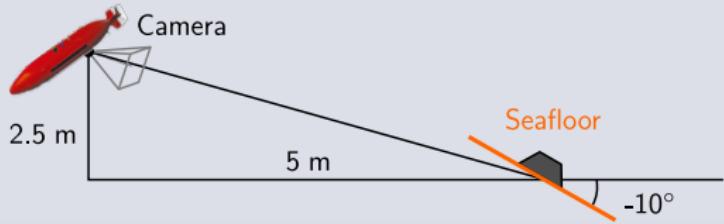
# Results

Looking at the viewer



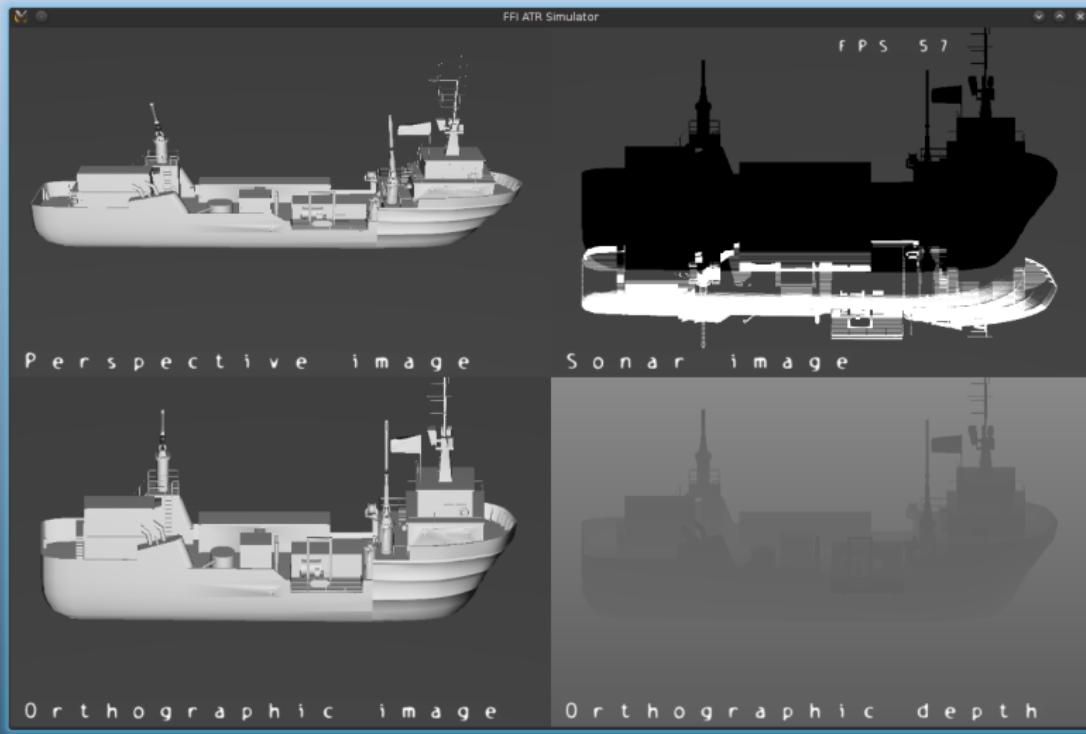
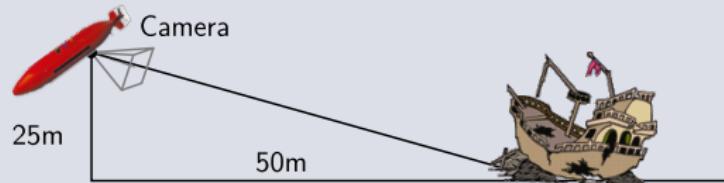
# Results

Looking at the viewer



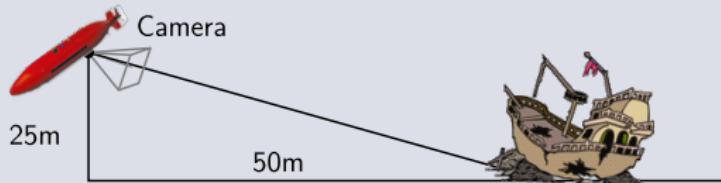
# Results

## A full ship!!!

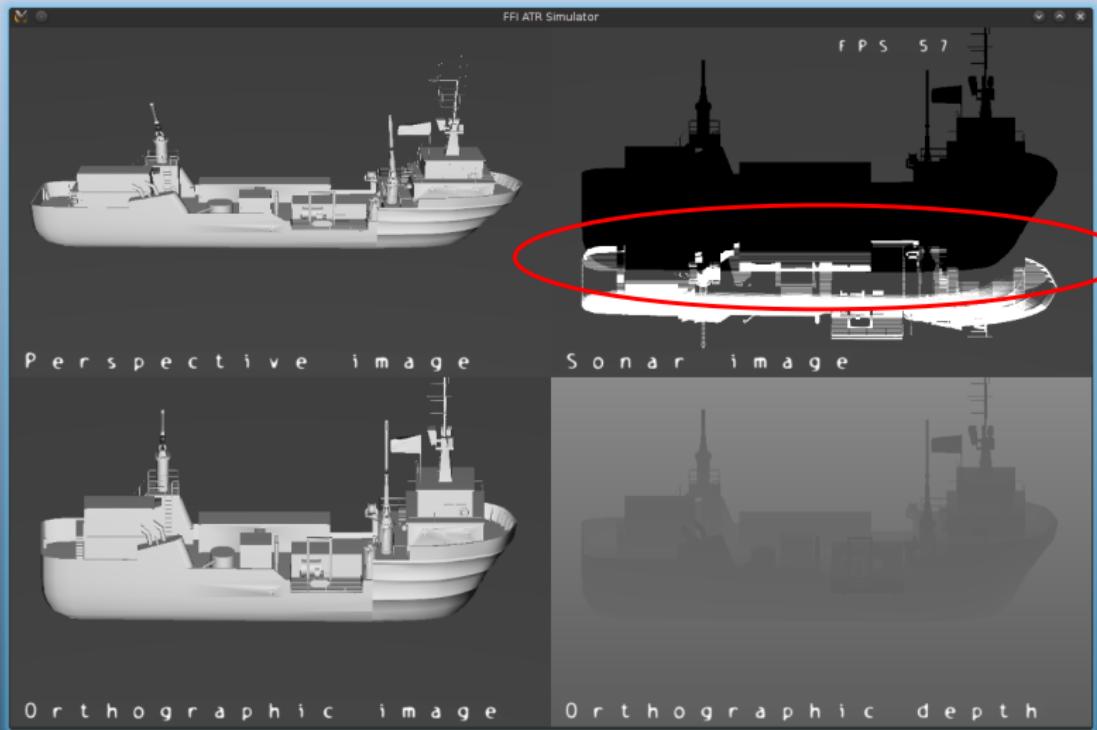


# Results

A full ship!!!

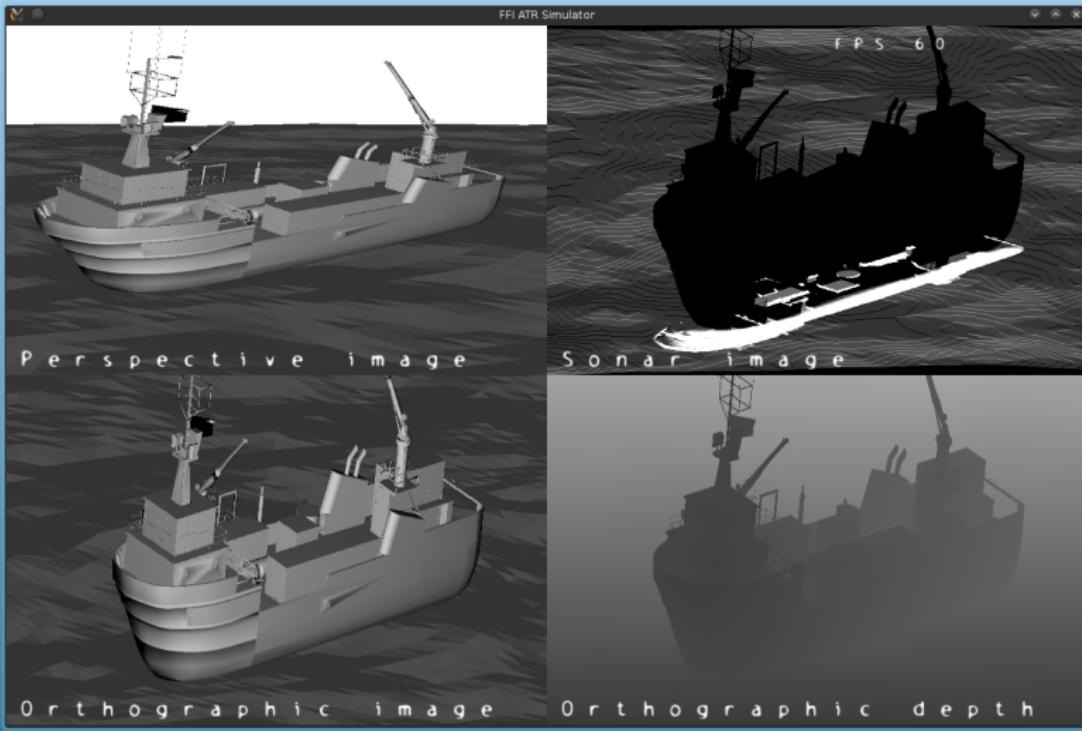
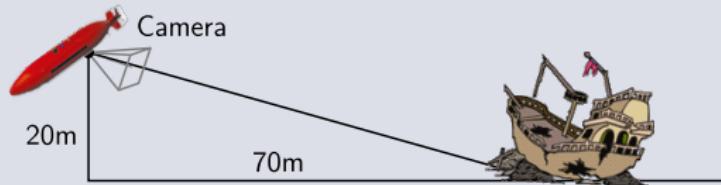


Lacking multipath?



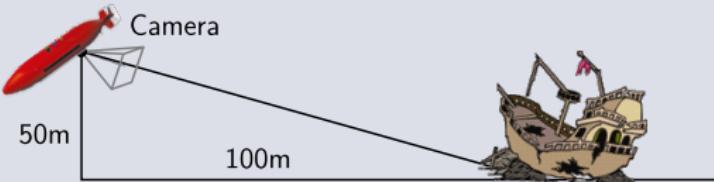
# Results

## A full ship!!!



# Results

## Compared to SSS



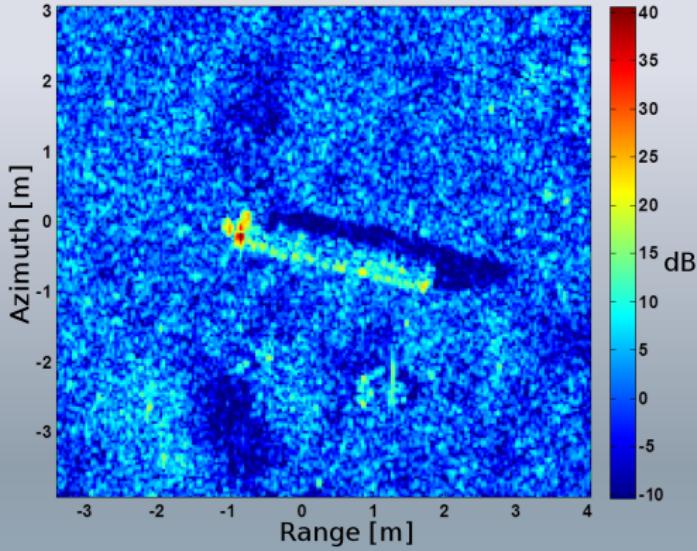
### Observations:

- Shadow has fair shape and size
- First part of highlight seems fine.
- Weird between highlight and shadow?



# Results

## HISAS image of a cylinder



### HISAS1030:

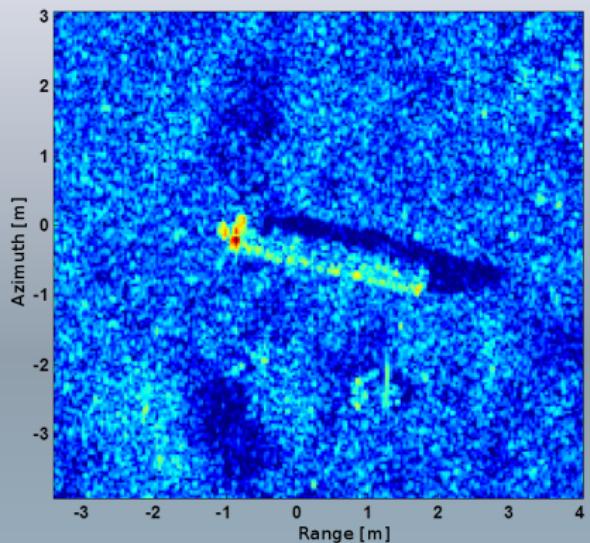
- Interferometric SAS
- Resolution: 3x3 cm
- TX/RX phased array: 2x32 elements
- Array length: 1.2 m
- Frequency: 100 kHz
- Opening angle: TX 15°, RX 23°

### Cylinder:

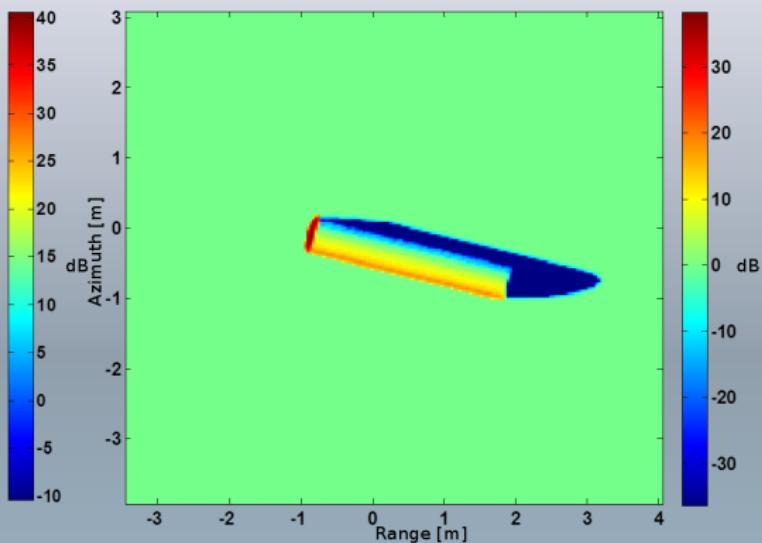
- Imaging range: 73 m
- Length: 2.6 m
- Radius: 0.53 m
- Submersion depth: 0.26 m

# Results

SAS and template image compared



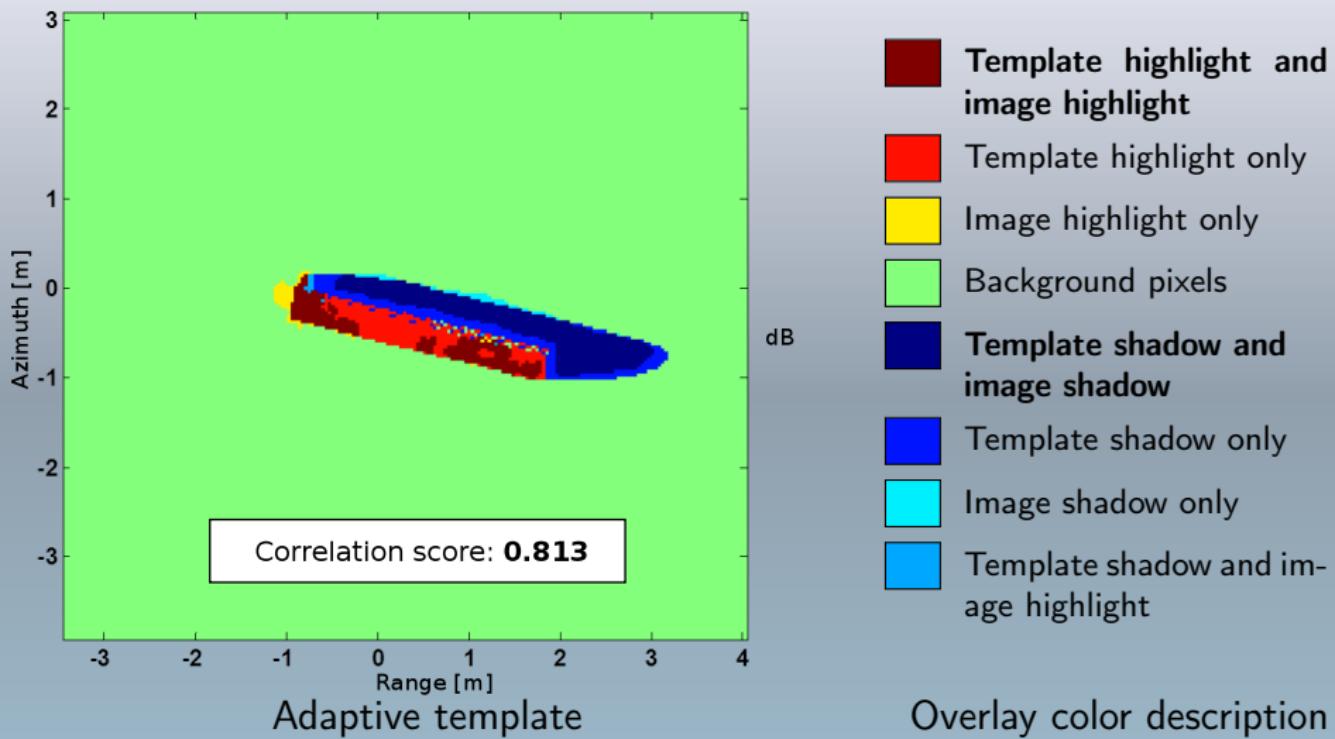
SAS image



Simulated template

# Results

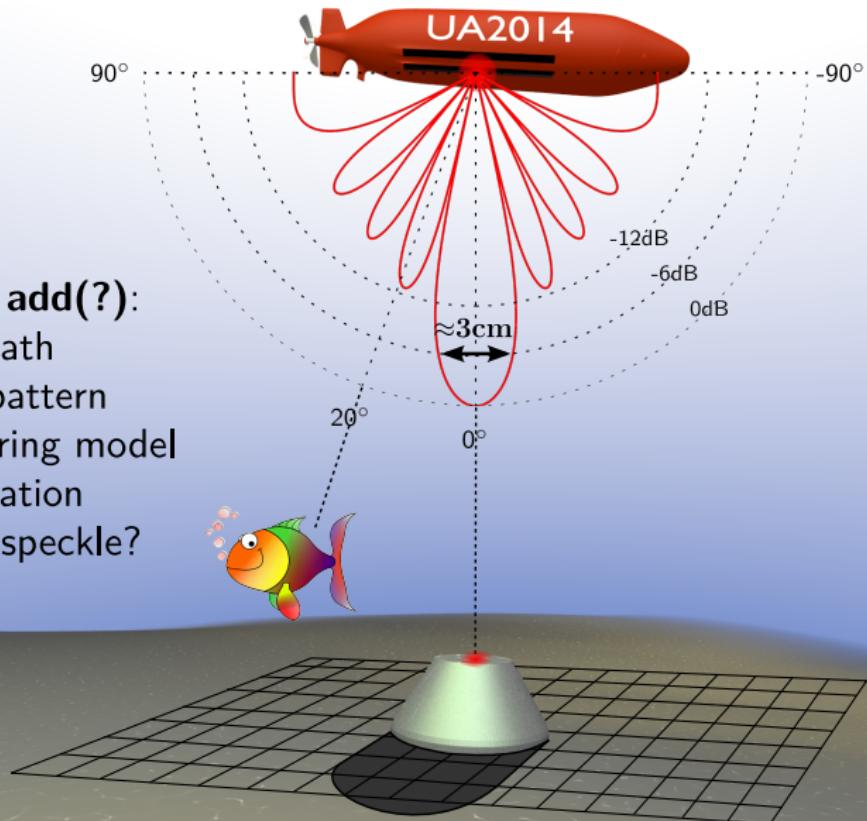
Overlay of segmented SAS image and segmented template image



# Future work

## Stuff to add(?)

- Multipath
- Beampattern
- Scattering model
- Penetration
- Noise/speckle?
- ?



# Conclusions

- ▶ Sonar templates generated @ 100+ FPS on a regular GPU, using
  - ▶ OpenGL to capture a “camera” version the scene as seen from the sonar, and
  - ▶ OpenCL to convert the OpenGL image with corresponding depth information to a ranged sonar-like image.
- ▶ Image quality
  - ▶ Shape and size seems ok.
  - ▶ Fishy stuff going on in the transition of highlight/shadow
- ▶ What to improve?

## Acknowledgements:

- ▶ Thanks to Kongsberg Maritime for making great hardware and to FFI for the assignment of developing the simulator.