

# Direct hole ice simulations with Upgrade-like geometry

## IceCube Calibration Call 2018-10-19

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Erlangen Centre for Astroparticle Physics

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**ICECUBE**  
SOUTH POLE NEUTRINO OBSERVATORY



**FAU**

FRIEDRICH-ALEXANDER  
UNIVERSITÄT  
ERLANGEN-NÜRNBERG

# Resources

**Scripts and plots for this talk:**

<https://github.com/fiedl/hole-ice-study/issues/117>

**YouTube video with Steamshovel vizualition:**

[https://www.youtube.com/watch?v=M\\_QGNdGG9Ew](https://www.youtube.com/watch?v=M_QGNdGG9Ew)

Thesis (2018-09-05) with more info on direct hole-ice simulation:

<https://github.com/fiedl/hole-ice-latex>

Previous talks:

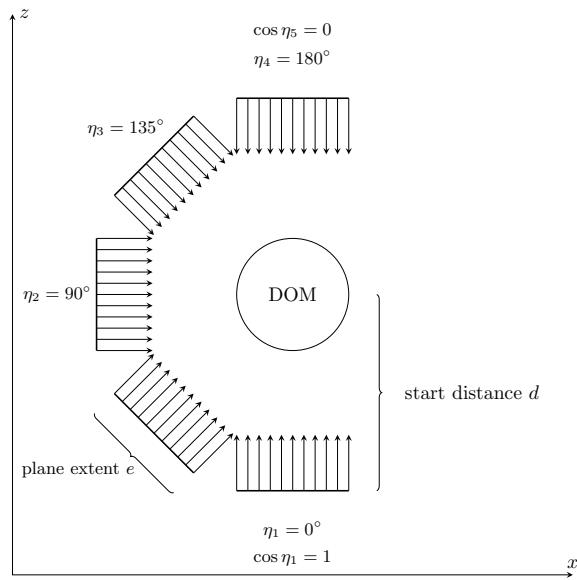
<https://github.com/fiedl/hole-ice-talk/releases>

**LATEX** version of these presentation slides:

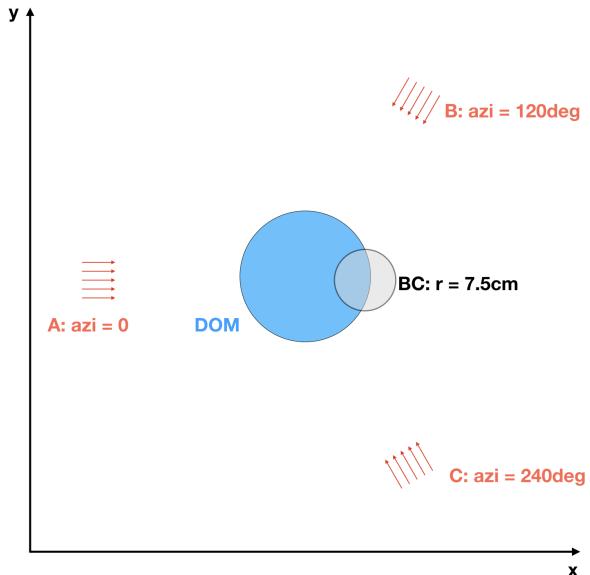
<https://github.com/fiedl/hole-ice-talk>

## Simulation scenario

For each angle polar and azimuthal angle, shoot photons onto the DOM, possibly propagate through the bubble column, and count hits.

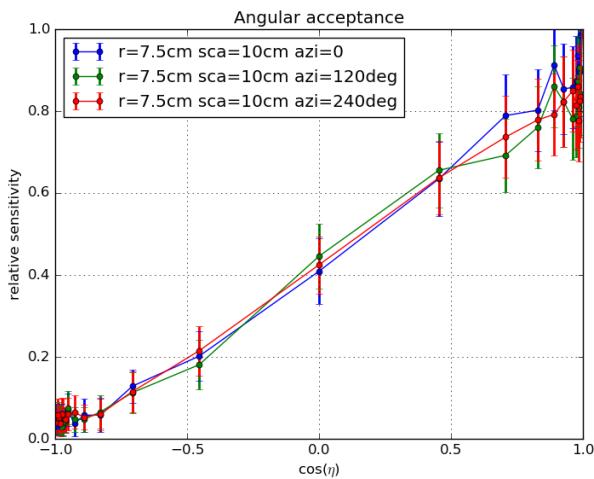


**Figure:** View from the side. Shooting photons from different polar angles.



**Figure:** View from above. Shooting photons from different azimuthal angles.

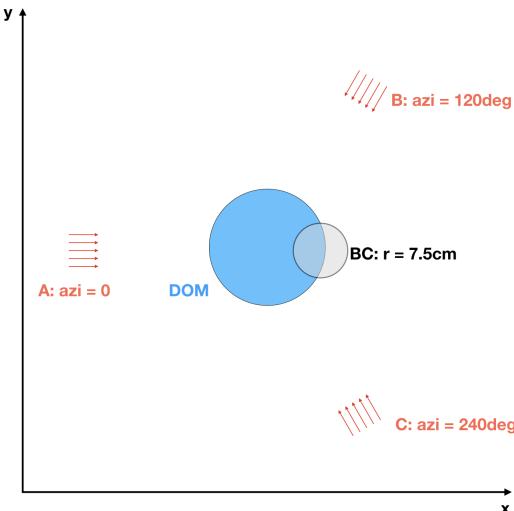
# Simulation results



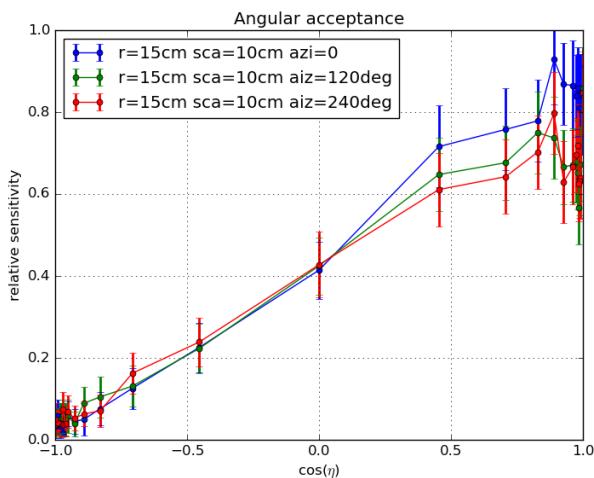
Total photon hit count: 12968 / 1e6

Configuration: Starting distance 3 m, plane-wave extent 3 m, bubble-column geometric scattering length 10 cm, bulk-ice geometric scattering length 130 cm.

- For lower polar angles ( $\cos \eta \approx 1$ ), less photons should arrive from azimuths B and C as from azimuth A as the DOM's PMTs look downwards and photons from B and C are more likely to cross the bubble-column cylinder.
- From azimuths B and C, the same number of photons should arrive due to the symmetry of the scenario (right image).



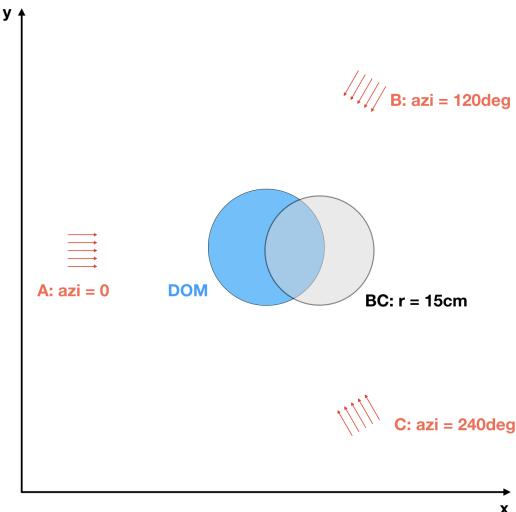
# Simulation results



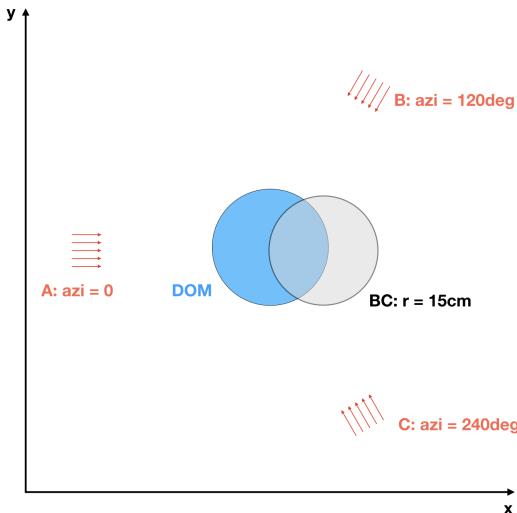
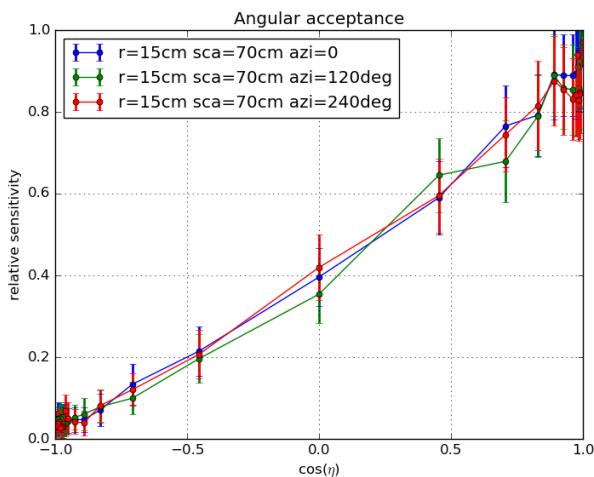
Total photon hit count: 11600 / 1e6

Configuration: Starting distance 3 m, plane-wave extent 3 m, bubble-column geometric scattering length 10 cm, bulk-ice geometric scattering length 130 cm.

- For a larger bubble column with same scattering lenght, the effect should increase. ✓



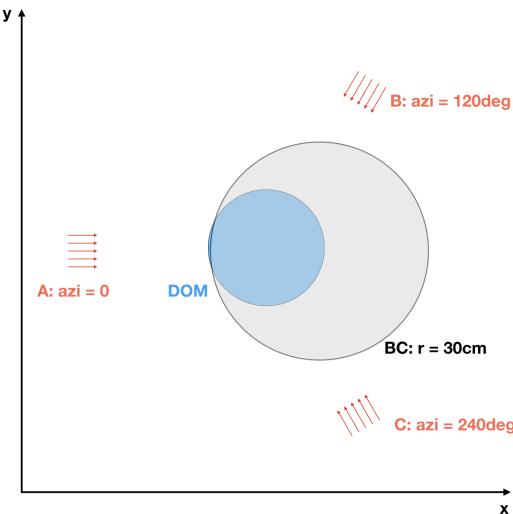
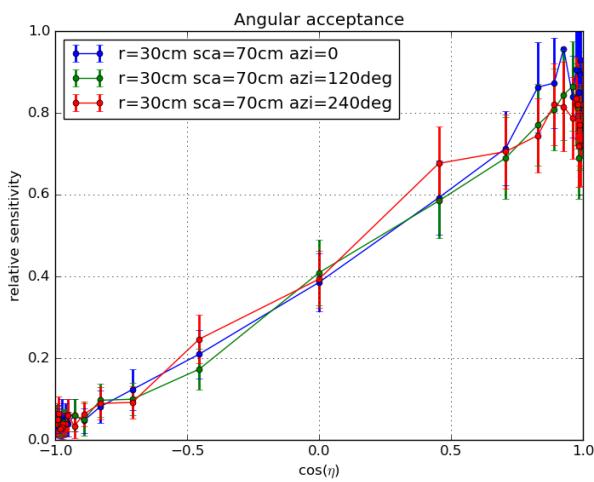
# Simulation results



Configuration: Starting distance 3 m, plane-wave extent 3 m, bubble-column geometric scattering length 70 cm, bulk-ice geometric scattering length 130 cm.

- For a larger scattering length (weaker bubble column), the effect should decrease. ✓

# Simulation results

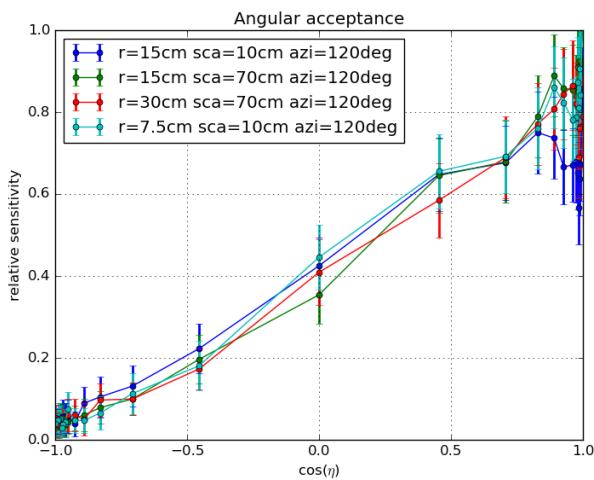


Total photon hit count: 12339 / 1e6

Configuration: Starting distance 3 m, plane-wave extent 3 m, bubble-column geometric scattering length 70 cm, bulk-ice geometric scattering length 130 cm.

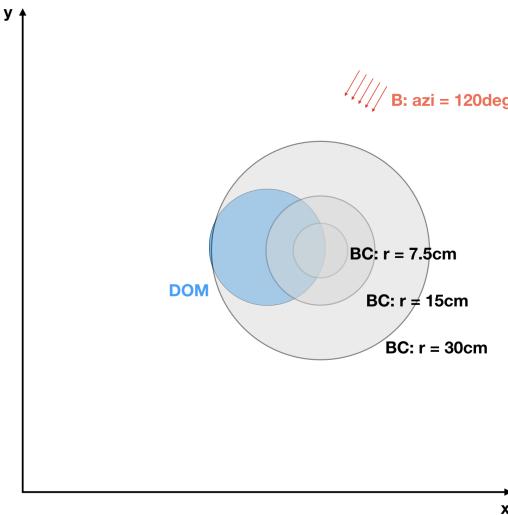
- For a larger bubble column, the effect should increase.
- Less photons should arrive in total as the whole DOM is now shielded by the hole ice. ✓

# Simulation results



Configuration: Starting distance 3 m, plane-wave extent 3 m, bulk-ice geometric scattering length 130 cm.

- Comparing different bubble columns for the same direction of incoming photons.
- For a stronger or larger bubble column, the effect should increase.

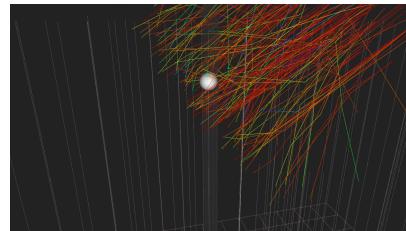


Thanks for your attention!

Any input you might have is welcome:

<https://github.com/fiedl/hole-ice-study/issues/117>

Slack: @sblot & @fiedl



YouTube video of the simulation:

[https://www.youtube.com/watch?v=M\\_QGNdGG9Ew](https://www.youtube.com/watch?v=M_QGNdGG9Ew)