

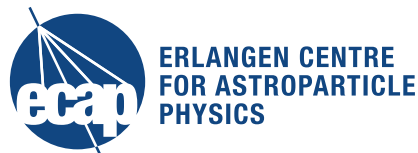
# Multi-PMT optical module for deep ice detectors in Antarctica

ERLANGEN CENTRE  
FOR ASTROPARTICLE  
PHYSICS

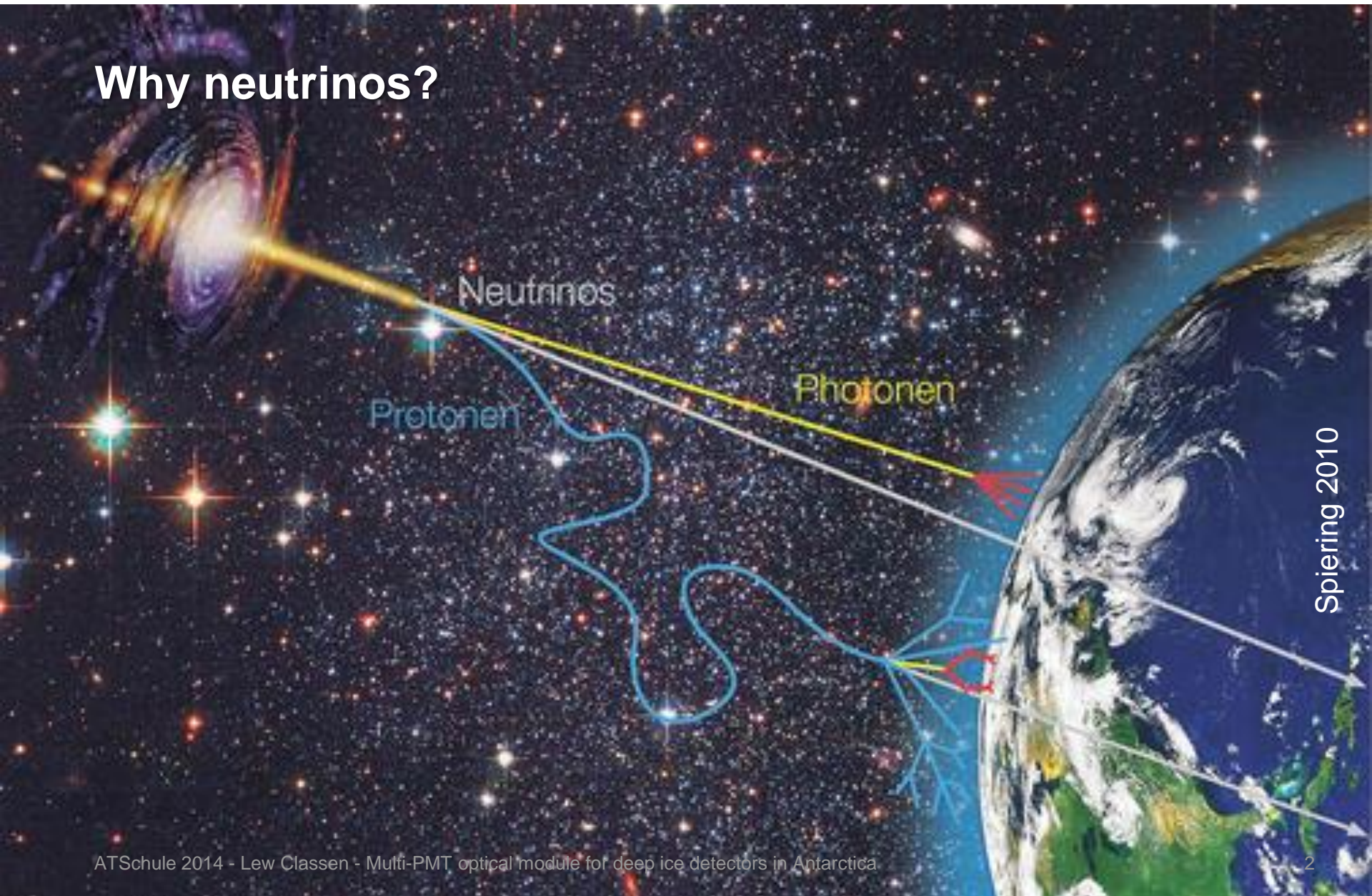
**Lew Classen**

AT Schule 2014

Bärnfels, 06.10.2014

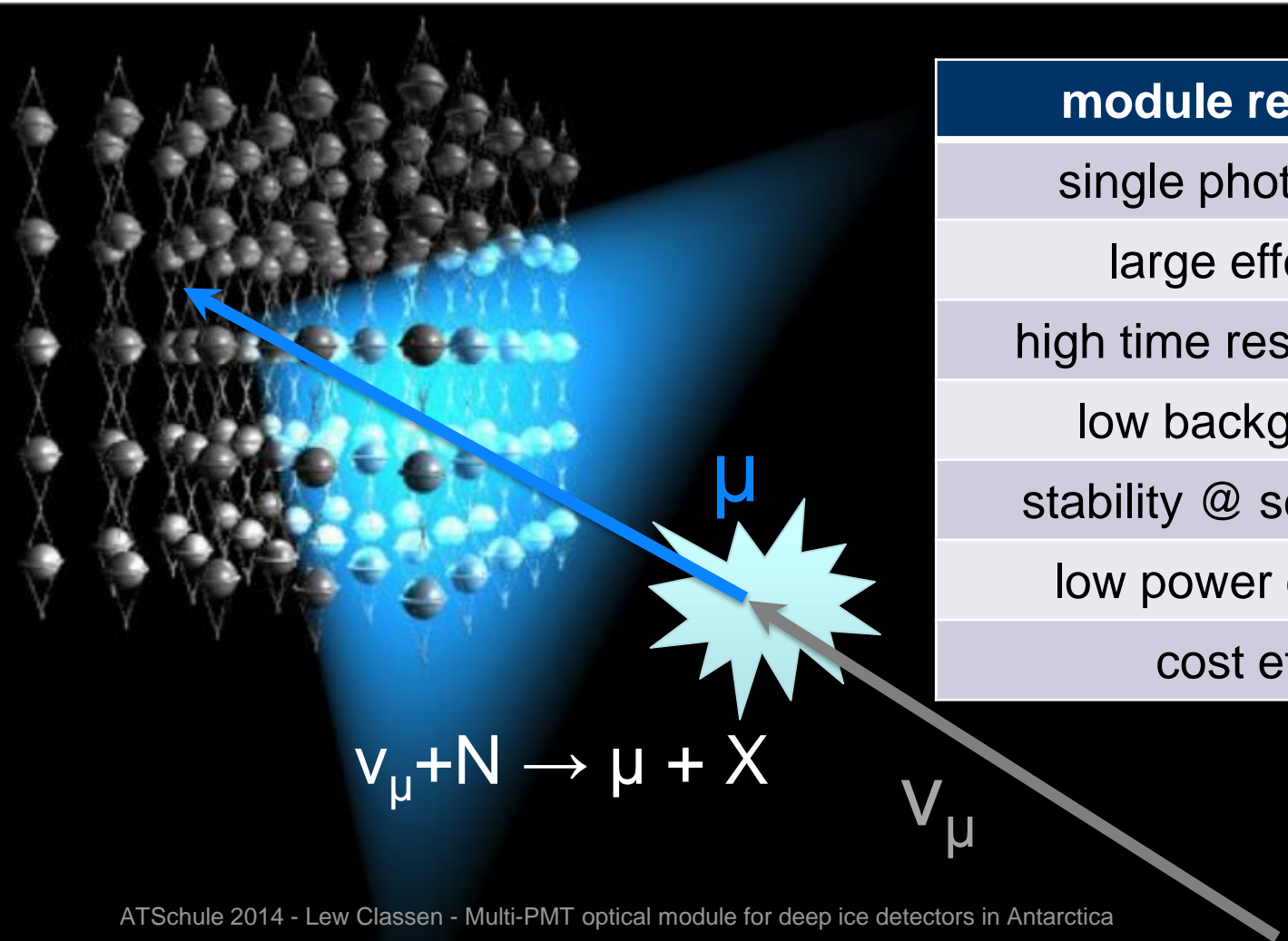


# Why neutrinos?



Spiering 2010

## Neutrino detection with H<sub>2</sub>O



### module requirements

single photon detection

large effective area

high time resolution ( $\sim 1\text{ns}$ )

low background rates

stability @ several 100 bar

low power consumption

cost efficiency



## Multi-PMT module



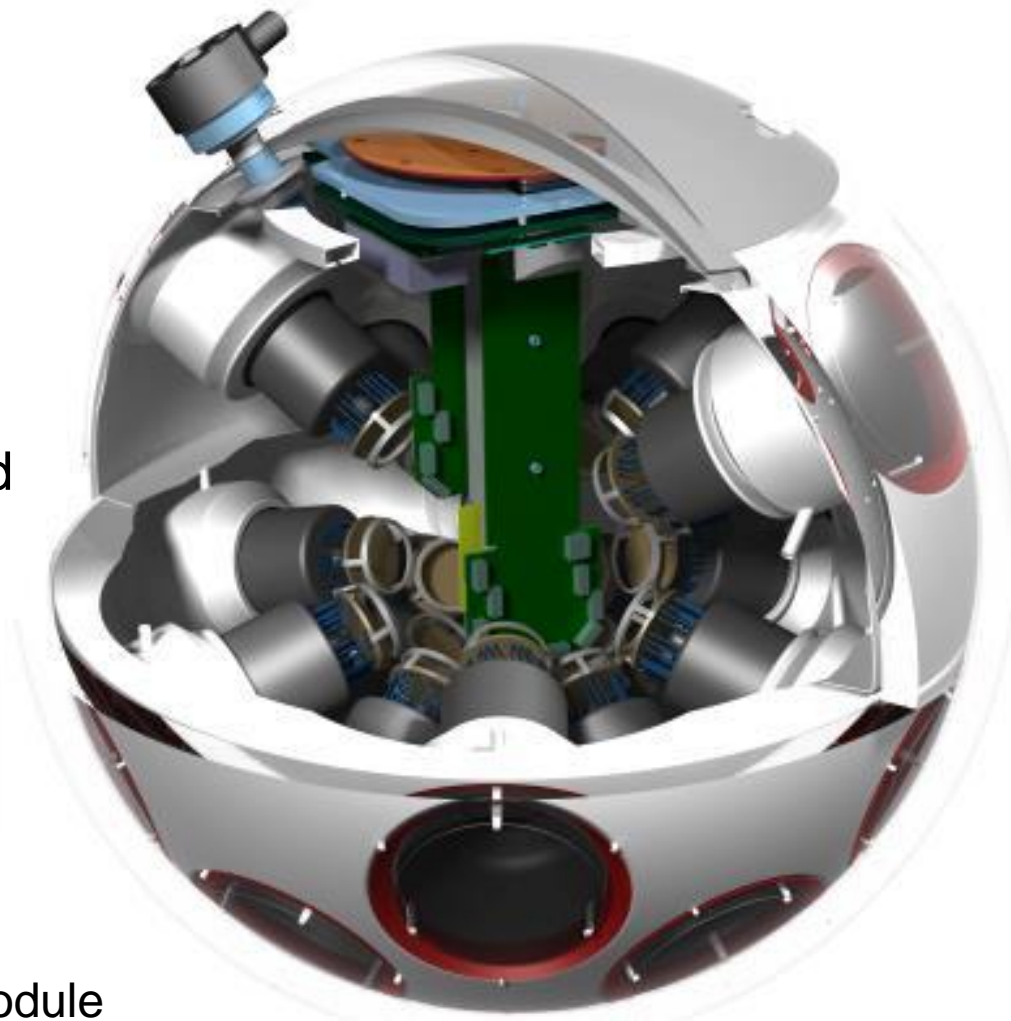
IceCube & Co	KM3NeT
13" sphere	17" sphere
1 × 10" PMT	31 × 3" PMT

## Concept advantages

- tripled photocathode area\*
- local coincidences
- angular acceptance  $4\pi$
- directional sensitivity
- no magnetic shielding needed

**same price**  
per photocathode area\*

\*compared to standard IceCube module





## PPM - DOM

- first multi-PMT module installed inside ANTARES framework
- operating since April 2013
- physics with only one module

## Adaptation for the use in deep ice

### reuse

PMTs

bases

connectors

### adaptation/ new development

pressure vessel

PMT holder

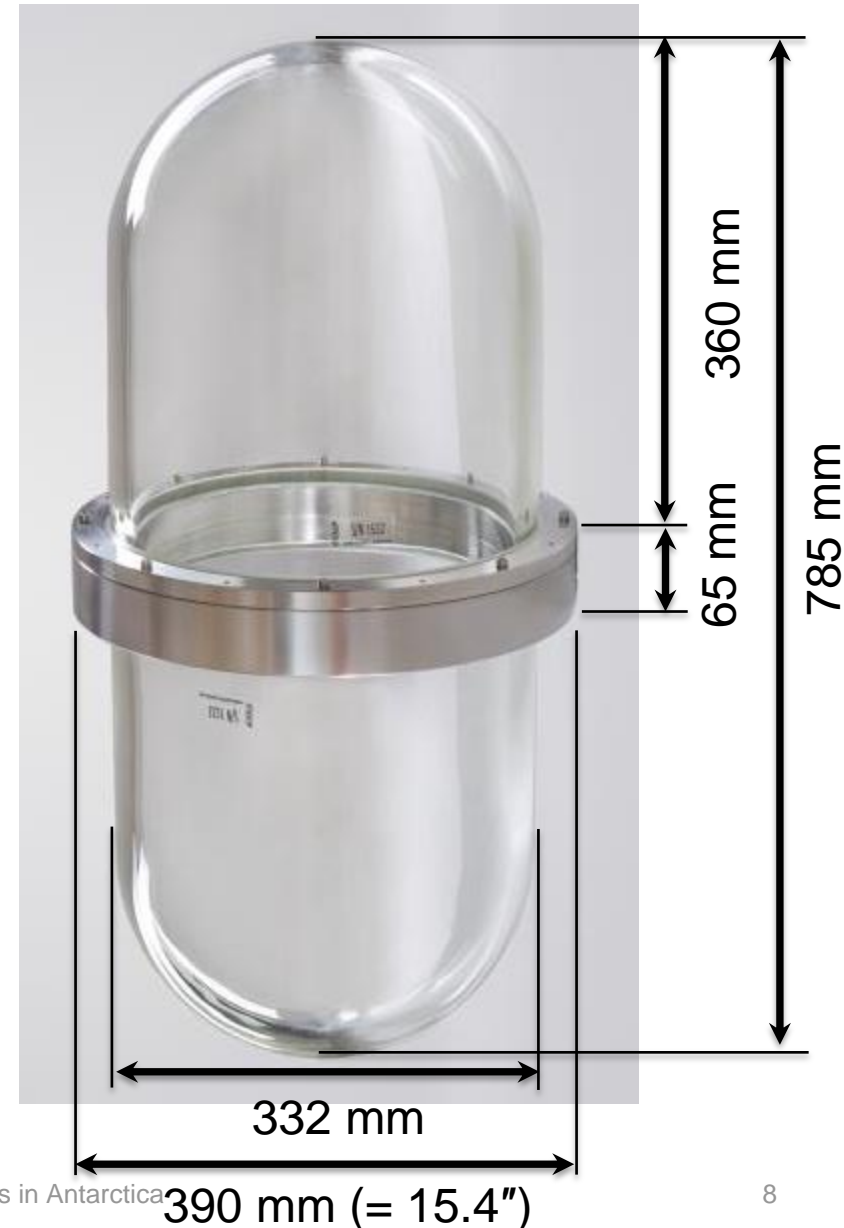
reflectors

electronics



## Cylindrical pressure vessel

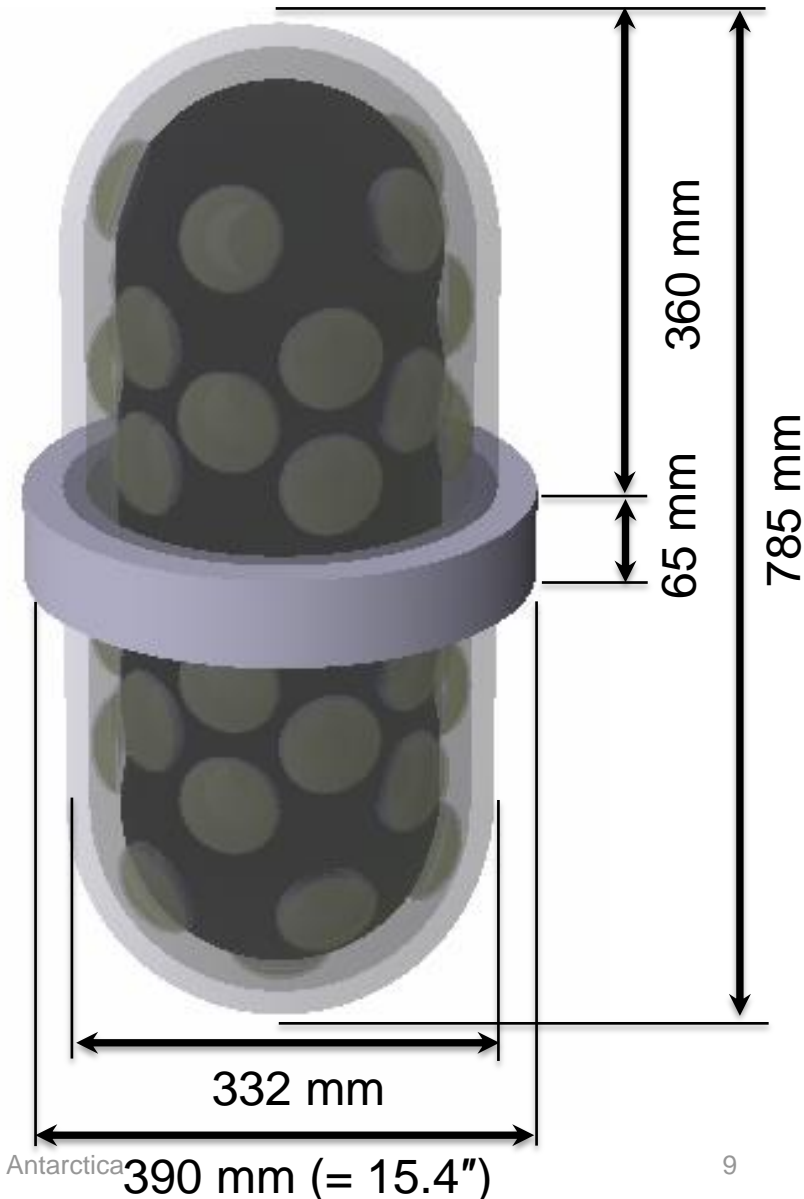
- wall thickness up to 18 mm
- rated for 700 bar
- steel connectors
- mass (f/m): 28,2 kg/22,5 kg
- main board in center
- increase of total length by additional cylinders possible



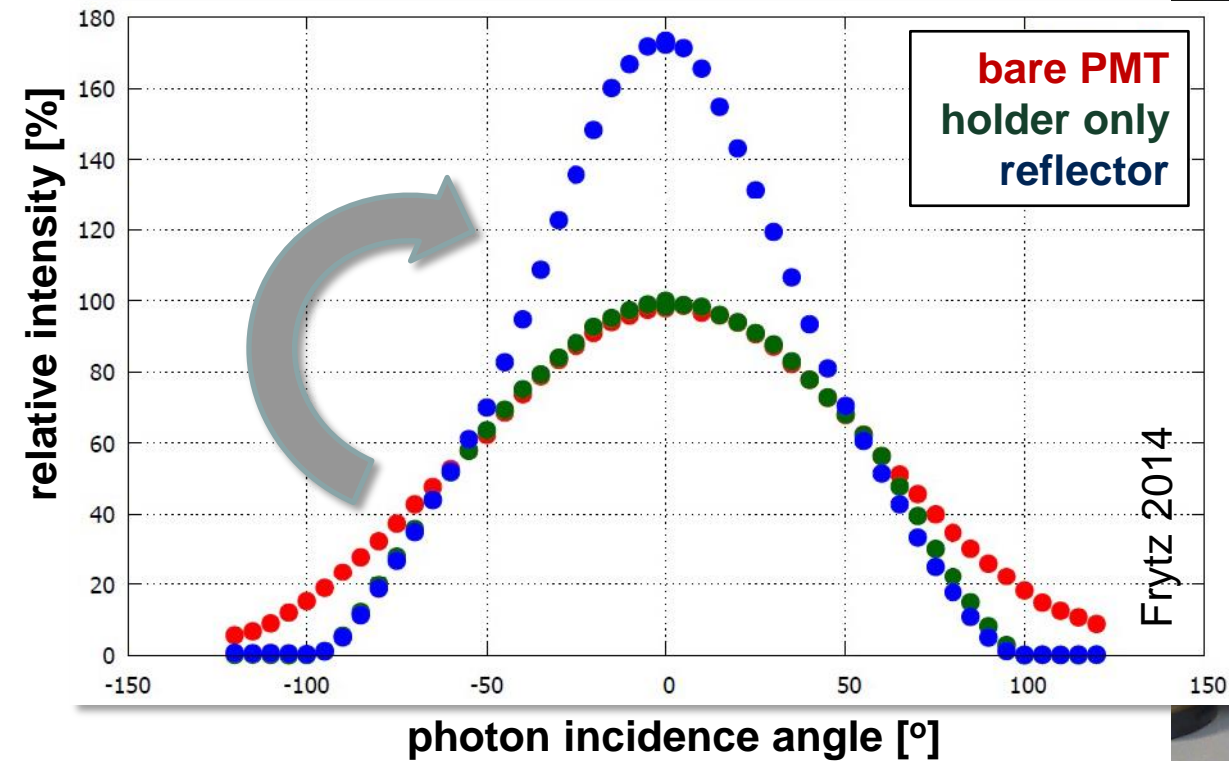


## multi-PMT DOM (mDOM)

- wall thickness up to 18 mm
- rated for 700 bar
- steel connectors
- mass (f/m): 28,2 kg/22,5 kg
- main board in center
- increase of total length by additional cylinders possible



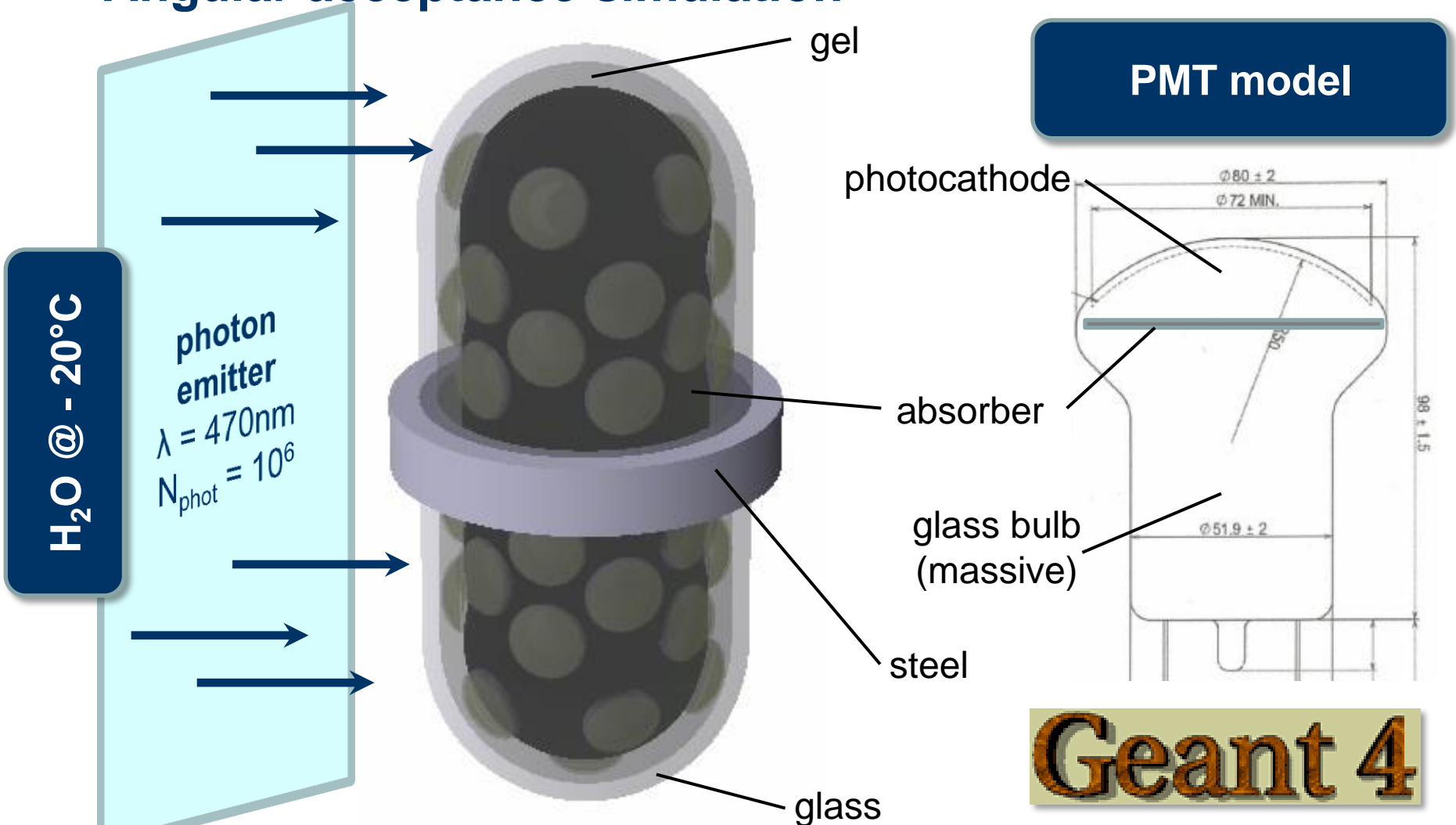
## Effect of reflectors



beamed acceptance



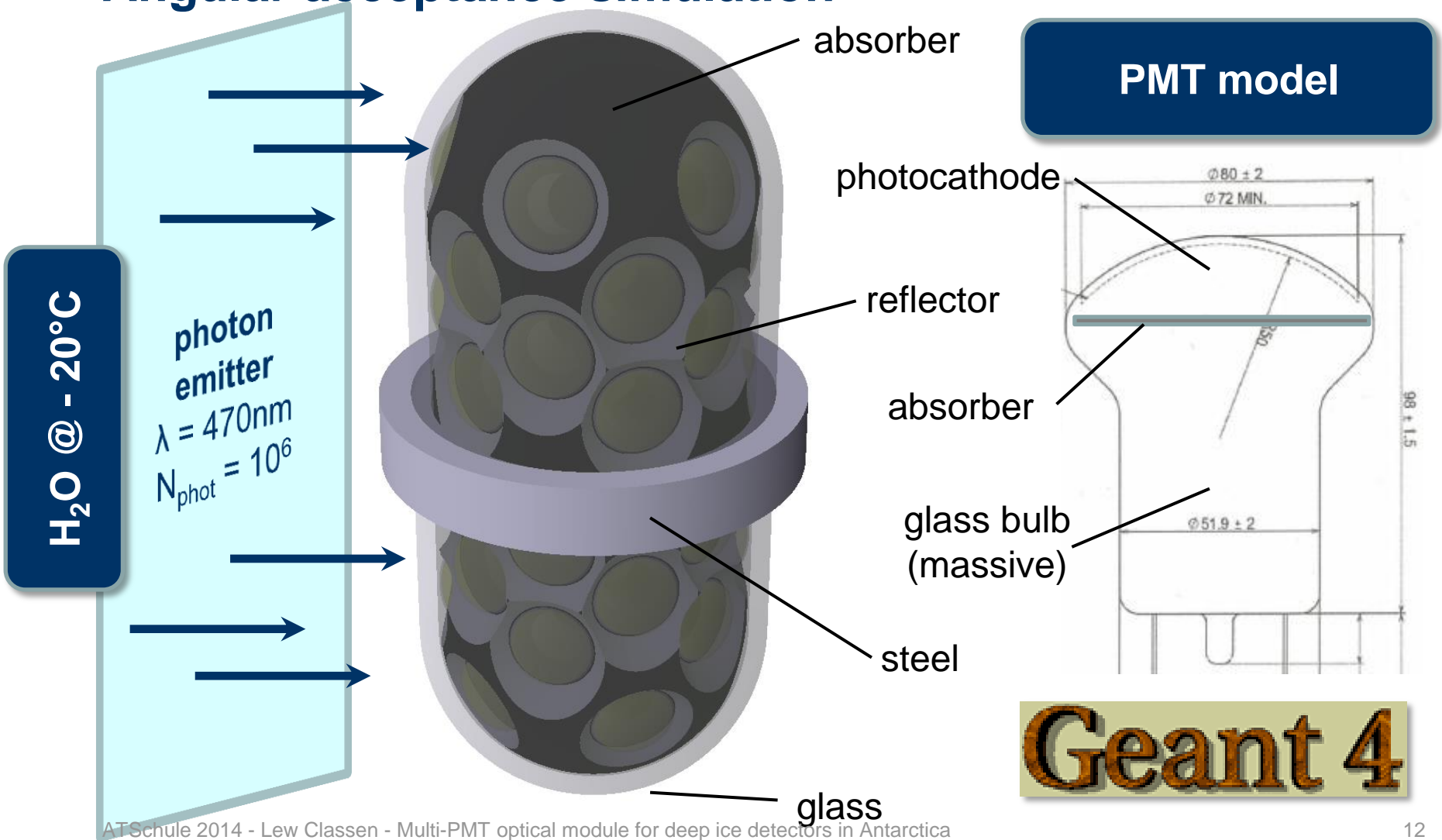
## Angular acceptance simulation



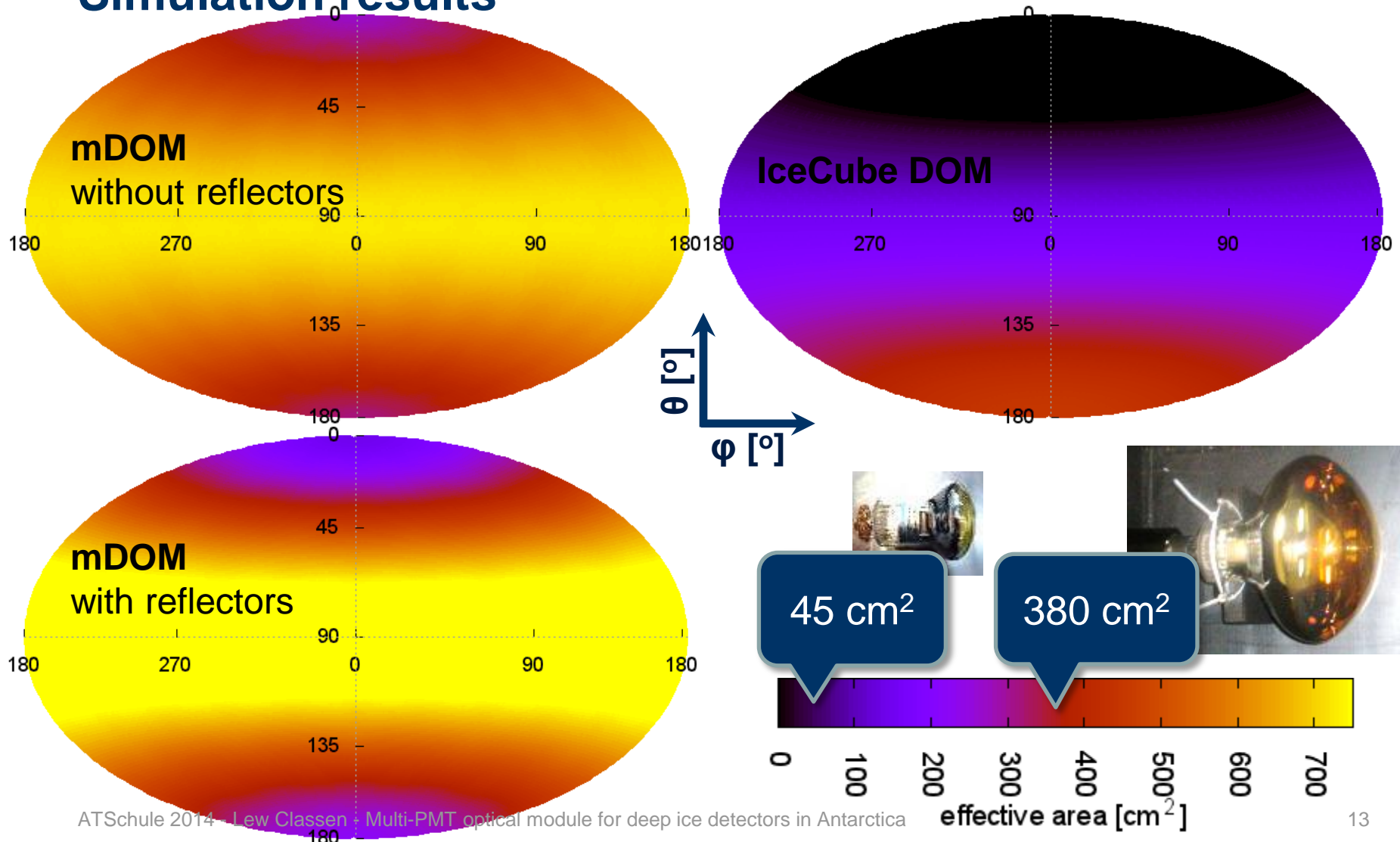
**Geant 4**



## Angular acceptance simulation



## Simulation results



# mDOM: opto-mechanical prototype





## Next Steps

**opto - mechanical  
prototype**

**measurement of module  
acceptance**

**background:  
simulation & measurement**

**electronics development**



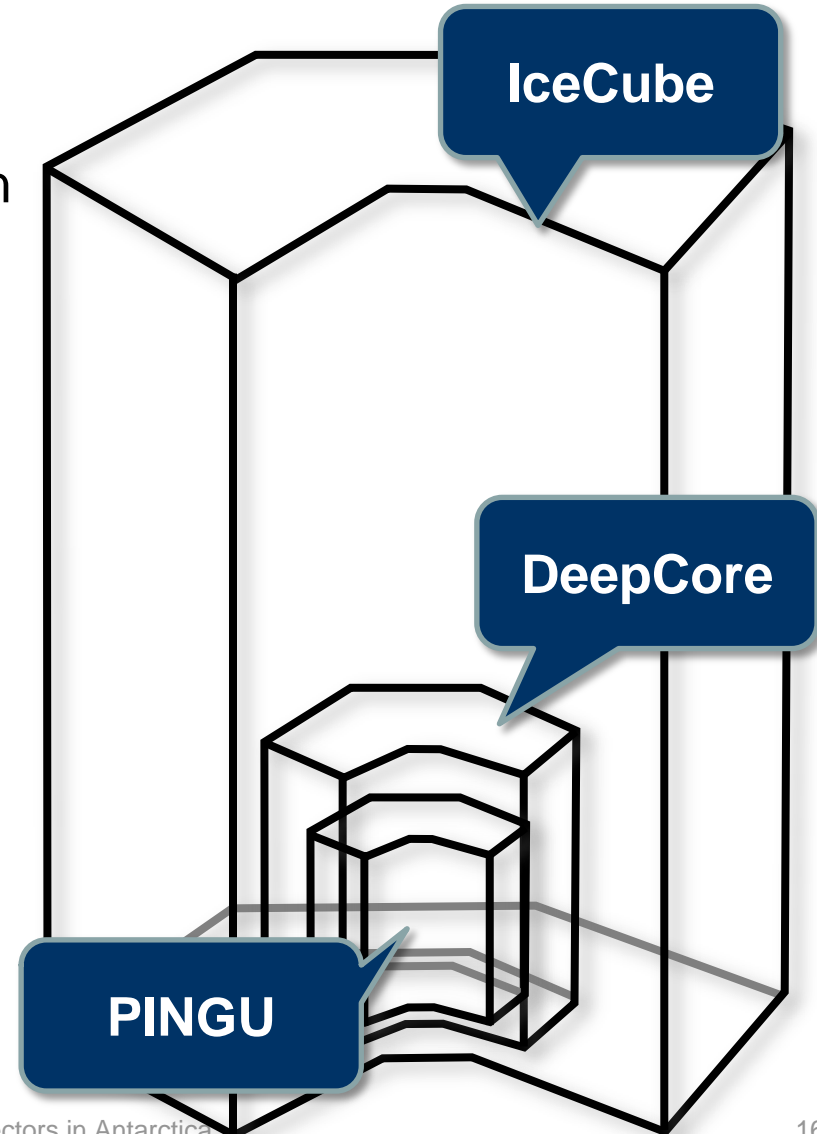
**mDOM prototype for  
deployment**

## PINGU

- **P**recision **I**ceCube **N**ext **G**eneration **U**ppgrade
- 40 additional strings
- standard instrumentation
- lower energy limit  $\sim$  GeV
- neutrino mass hierarchy

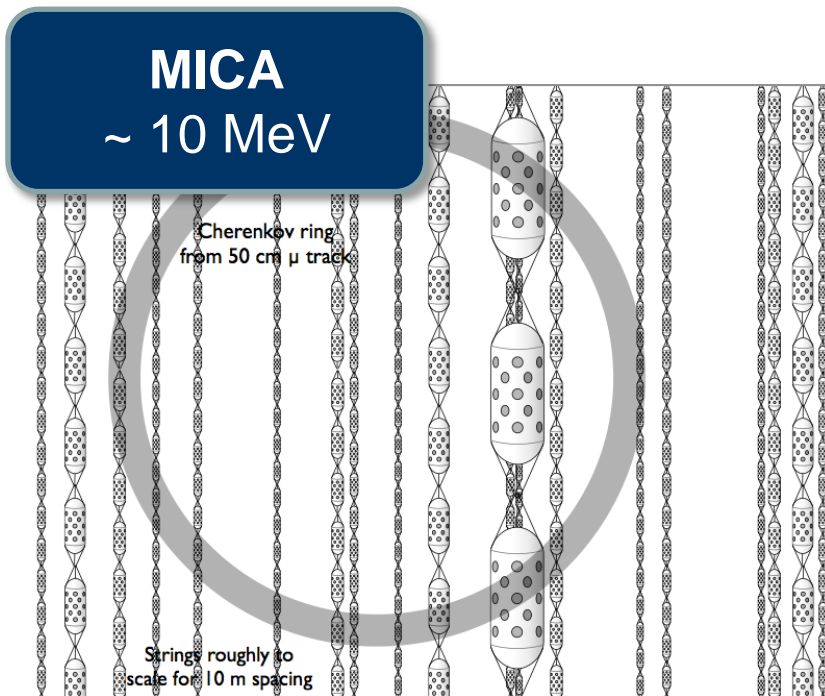
### mDOM - R&D

- installation of 2 mDOMs
- fully integrated read-out
- track reconstruction

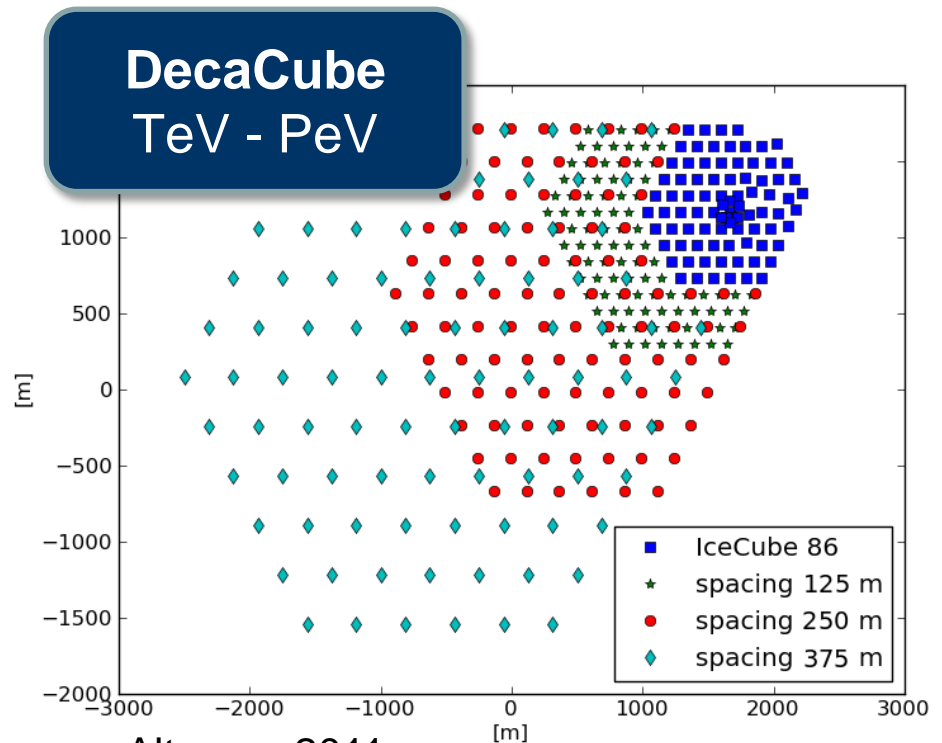


## Possible future use

- candidate for future deep ice detectors in Antarctica
- simulations ongoing



Grant 2011



Altmann 2011



# Thank you for your attention!

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