Investigating luminescence characteristics of ultra-purified water and ice

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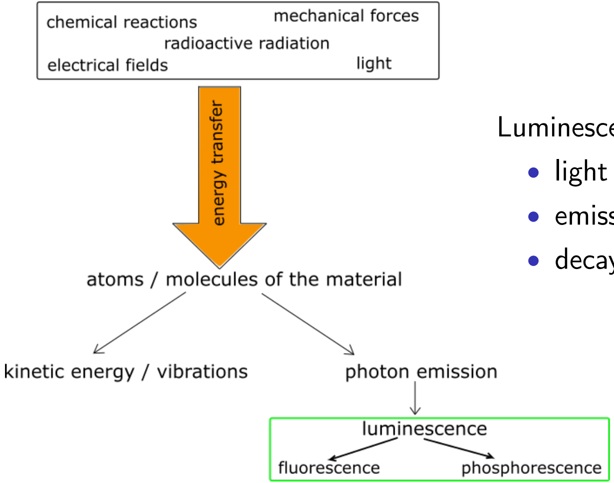
Production of luminescence



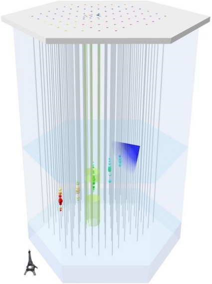
Luminescence characteristics:

- light yield
- emission spectrum
- decay kinetics

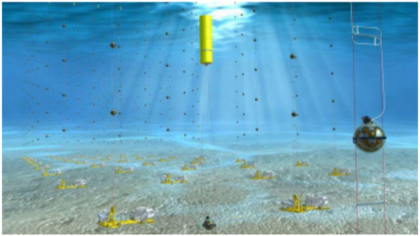
Motivation

- Luminescence is produced in water and ice cherenkov detectors
  - Can be used as a new detection channel for particles that do not produce Cherenkov light, e.g. low-relativistic magnetic monopoles
  - Needs to be considered for the detector calibration
  - → Therefore the luminescence characteristics of water and ice need to be known

ICECUBE
SOUTH POLE NEUTRINO OBSERVATORY



KM3NeT



Goals of our investigation

Lab measurements:

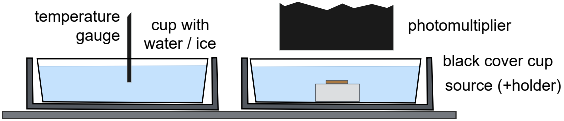
- Determining luminescence characteristics for water and ice in dependance of
  - temperature
  - pressure
  - charge
  - purity

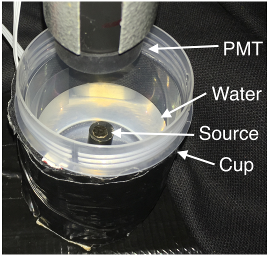
In-situ measurements:

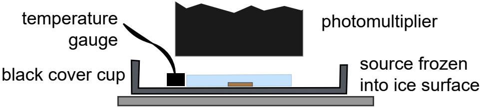
- Determining the luminescence characteristics of Antarctica ice on site
  $\rightarrow$ luminescence logger

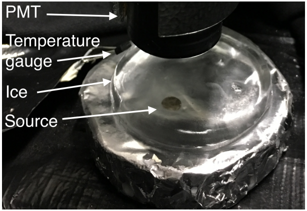
Setup for light yield measurement

- Production of luminescence light with α-particles from ^{241}Am-source

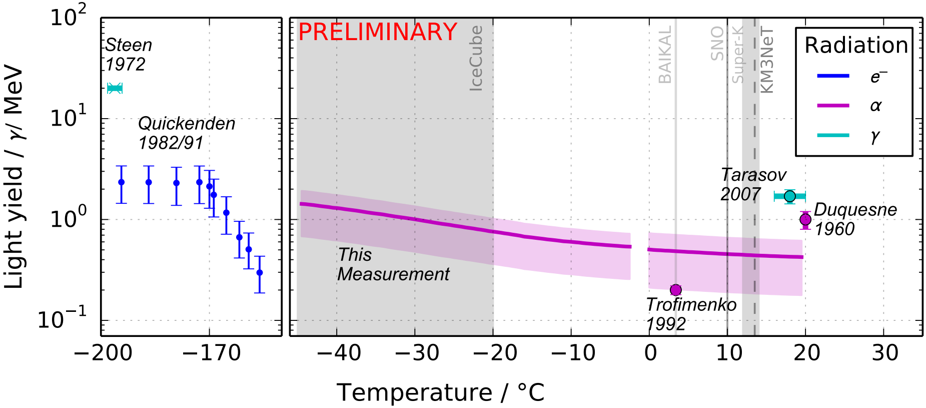








Light yield results



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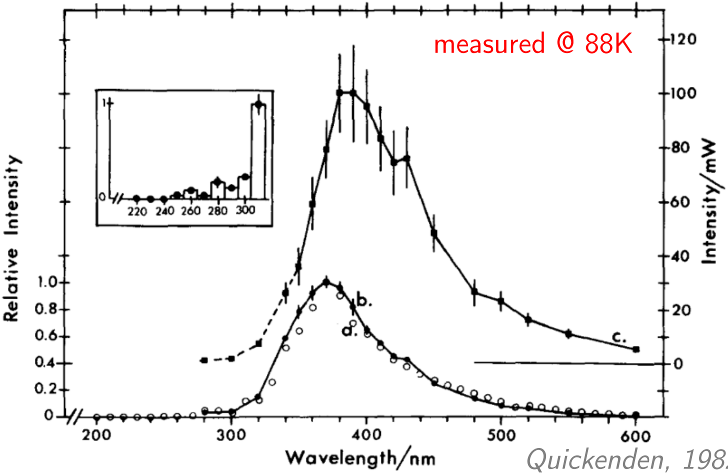
Luminescence spectrum

- Motivation: identifying electronic transitions in molecules contributing to luminescence
- Only a few investigations have been performed so far



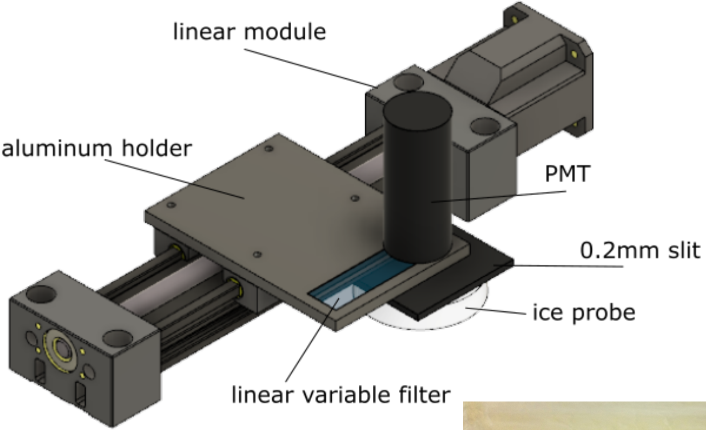
Quickenden, 1982

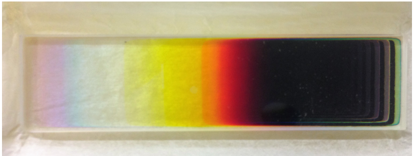
Choice of setup for spectral measurements

- Challenge: Very low detection rates due to low light yield
- Three different options were investigated concerning detection efficiency:

– Transmissive grating $\rightarrow 0.37\%$
– Monochromator $\rightarrow 0.077\%$
– Linear variable filter $\rightarrow 0.46\%$

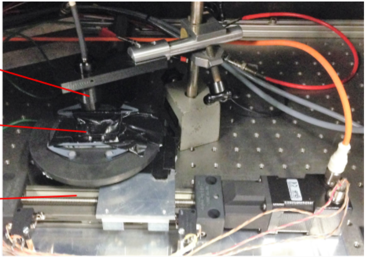
Experimental setup

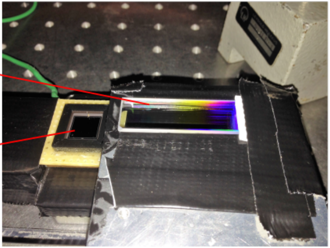




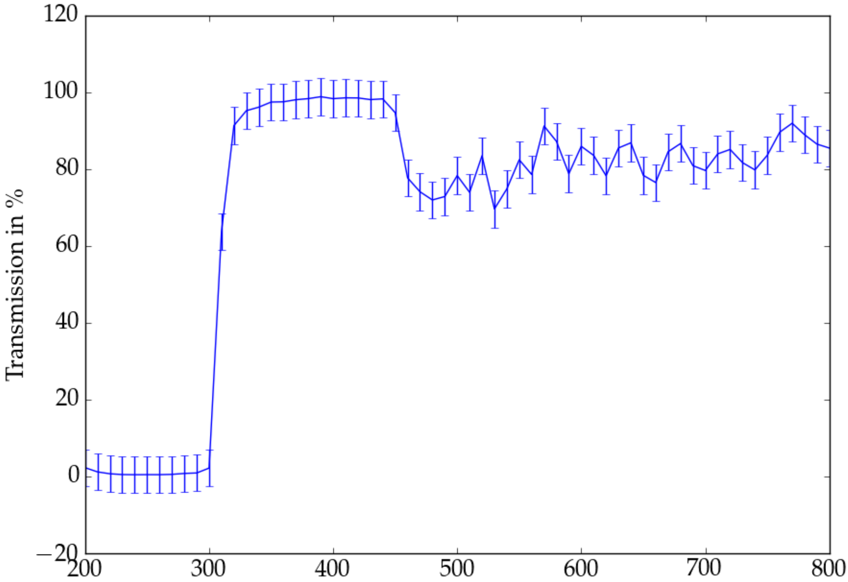
Calibration of the setup

- Measurement of transmission curves at different positions
- Using a tunable light source with 10nm steps and a calibrated photodiode





Calibration of the setup - results



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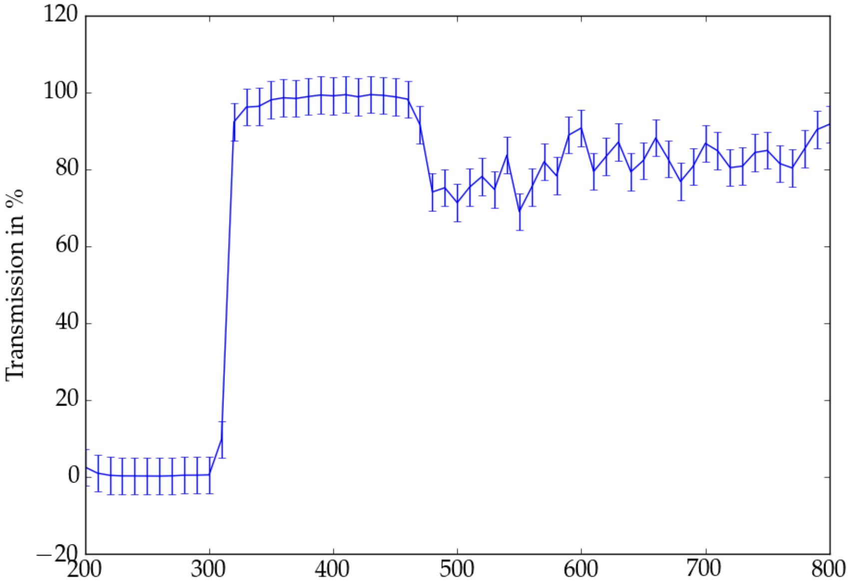

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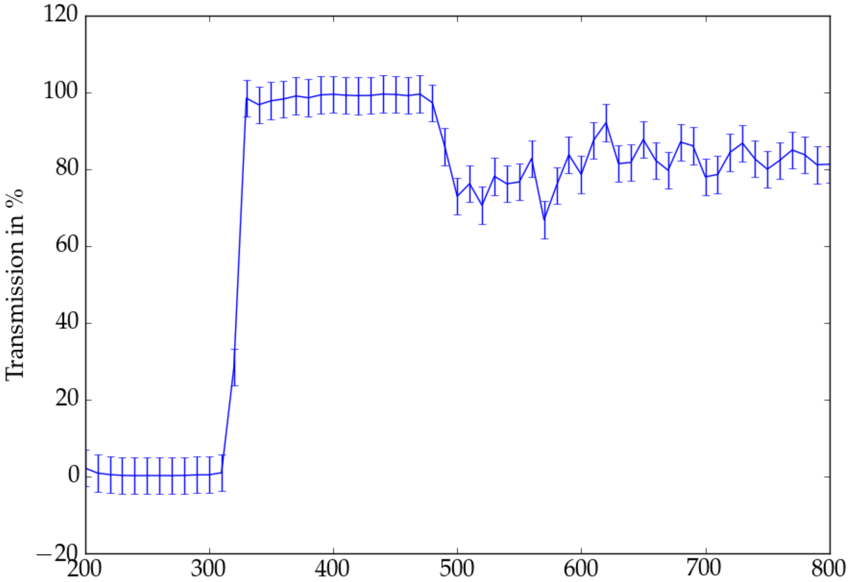

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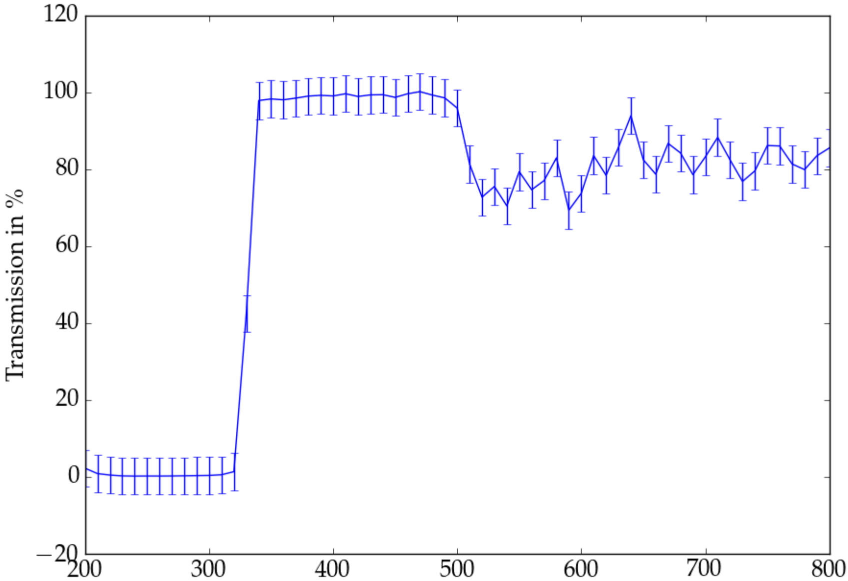
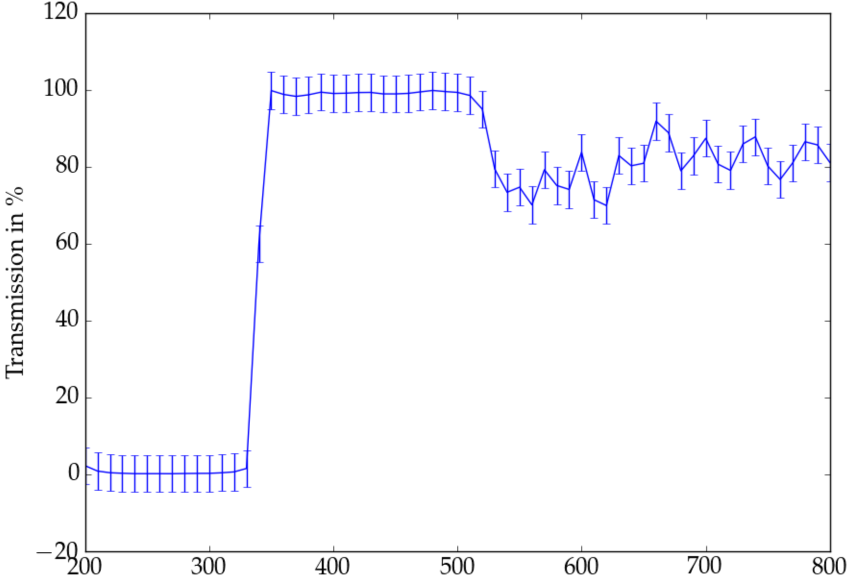


Calibration of the setup - results



Deconvolution of the signal

- Convolution of the unknown spectrum s and the response function of the filter A

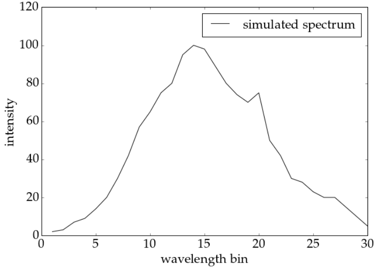
$$y(x) = \int A(x, \lambda) s(\lambda) d\lambda$$

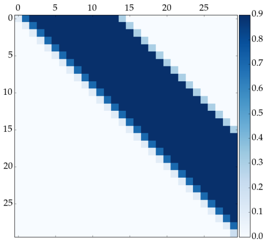
- In this case discretized form is used $\overrightarrow{y} = A \cdot \overrightarrow{s}$
- First try: solve by inverting the response matrix A
- This is an ill-posed problem, uncertainties of $\overrightarrow{y}$ and A lead to very high uncertainties in $\overrightarrow{s}$

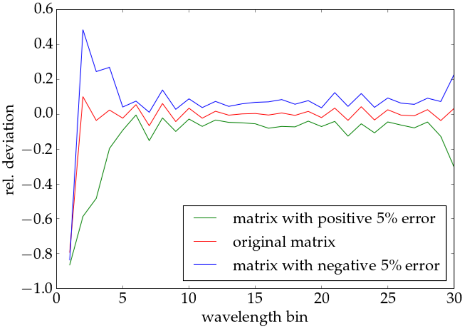
→ Regularisation is needed

Gold iteration

- Iteration of $\overrightarrow{s}$ using the recursion formula $s_i^{m+1} = s_i^m y_i' / \sum_{j=1}^{n} A_{ij}' s_j^m$







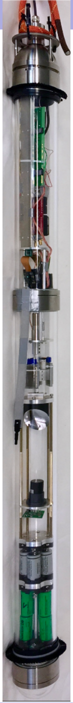
Measurement of the emission spectrum

- First measurements show that the measured rate is still to low

$\rightarrow$ New radioactive source with higher activity is needed

Outlook: Luminescence Logger

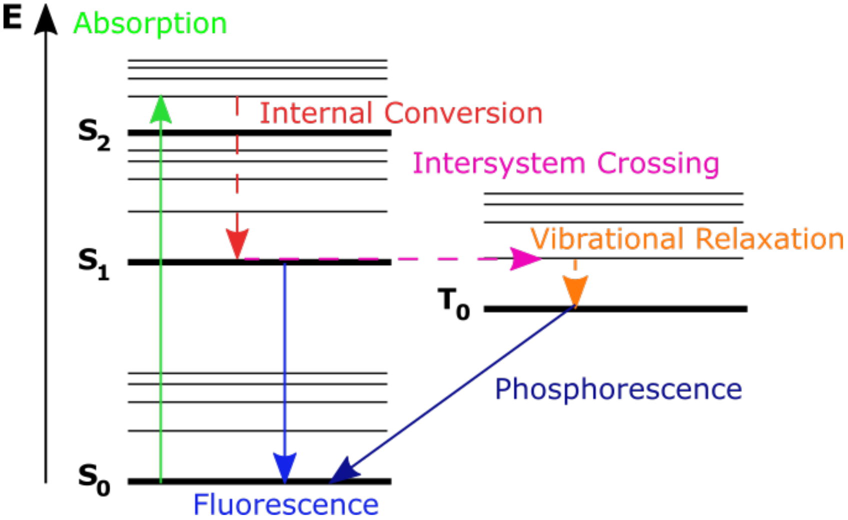
- Goal: Measure light yield and decay times of antarctica ice in different depths in the SPICE hole
- Production of luminescence with ^{36}Cl-source that emits β-radiation
- Measurements will be performed in november 2018



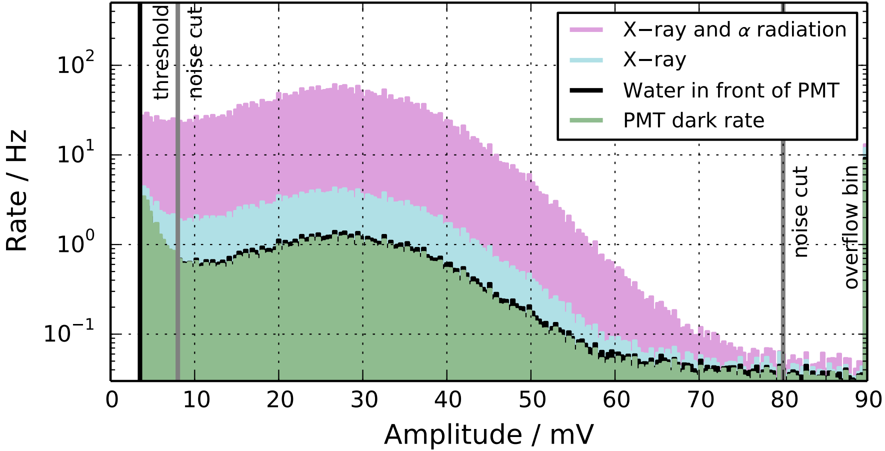
Summary

- Investigation of luminescence characteristics is ongoing
- Light yield and its temperature dependence has been determined in the temperature range $-40^{\circ}C$ to $20^{\circ}C$
- Setup for measurements of luminescene spectra has been developed and calibrated
- A new source is needed for measurements of luminescence spectra
- In november 2018, a device will be send to the south pole to measure luminescence characteristics of antarctica ice on site

Jablonski diagramm



Measuring principle



Temperature dependency of light yield