Wavelength-shifting Optical Module (WOM)

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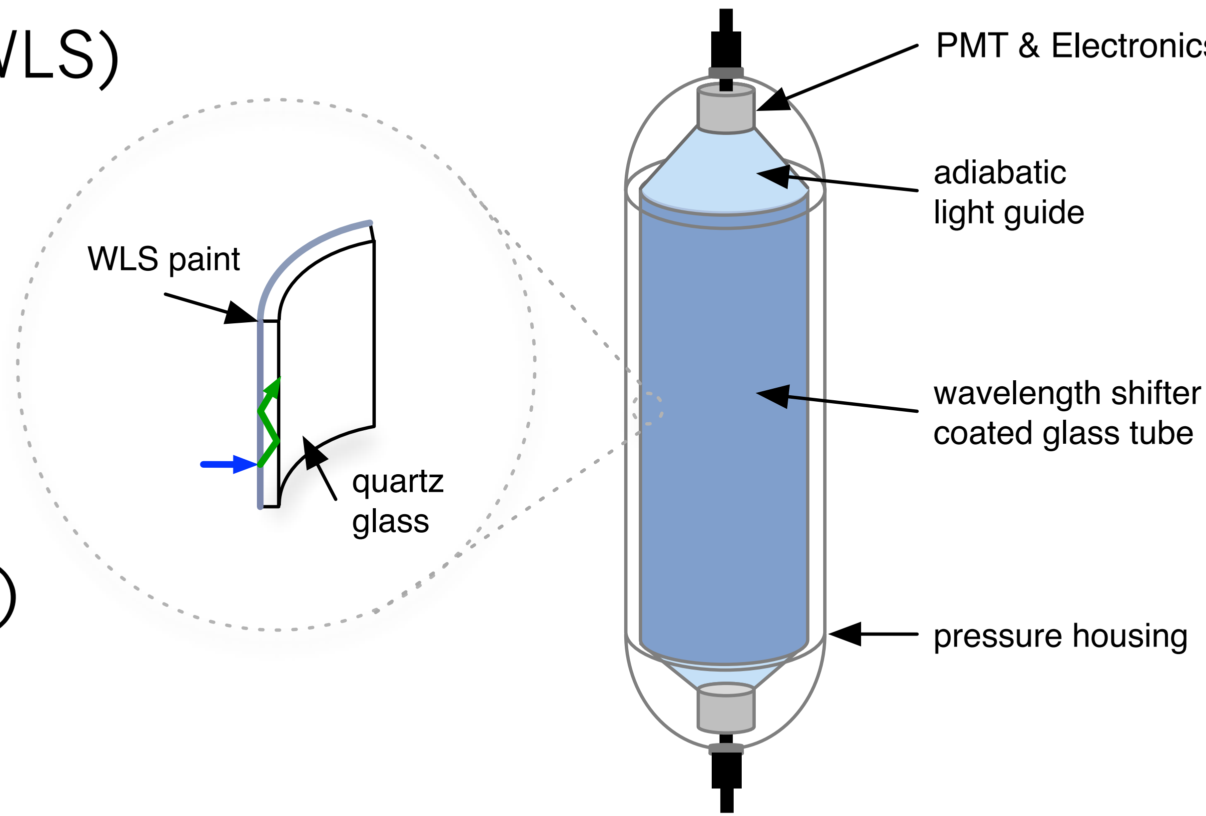
WOM idea

Basic concept

- Wavelength shifters (WLS)
  - concentrate light

Features

- large collection area
- low noise rate (few Hz)
- better UV sensitivity
- cost effective



WLS testing

Goal

- optimized WLS paint

Plastic carriers

- PMMA
  - Paraloid B82 / producer
  - soft
- PEMA
  - Paraloid B72
  - hard

Solvents

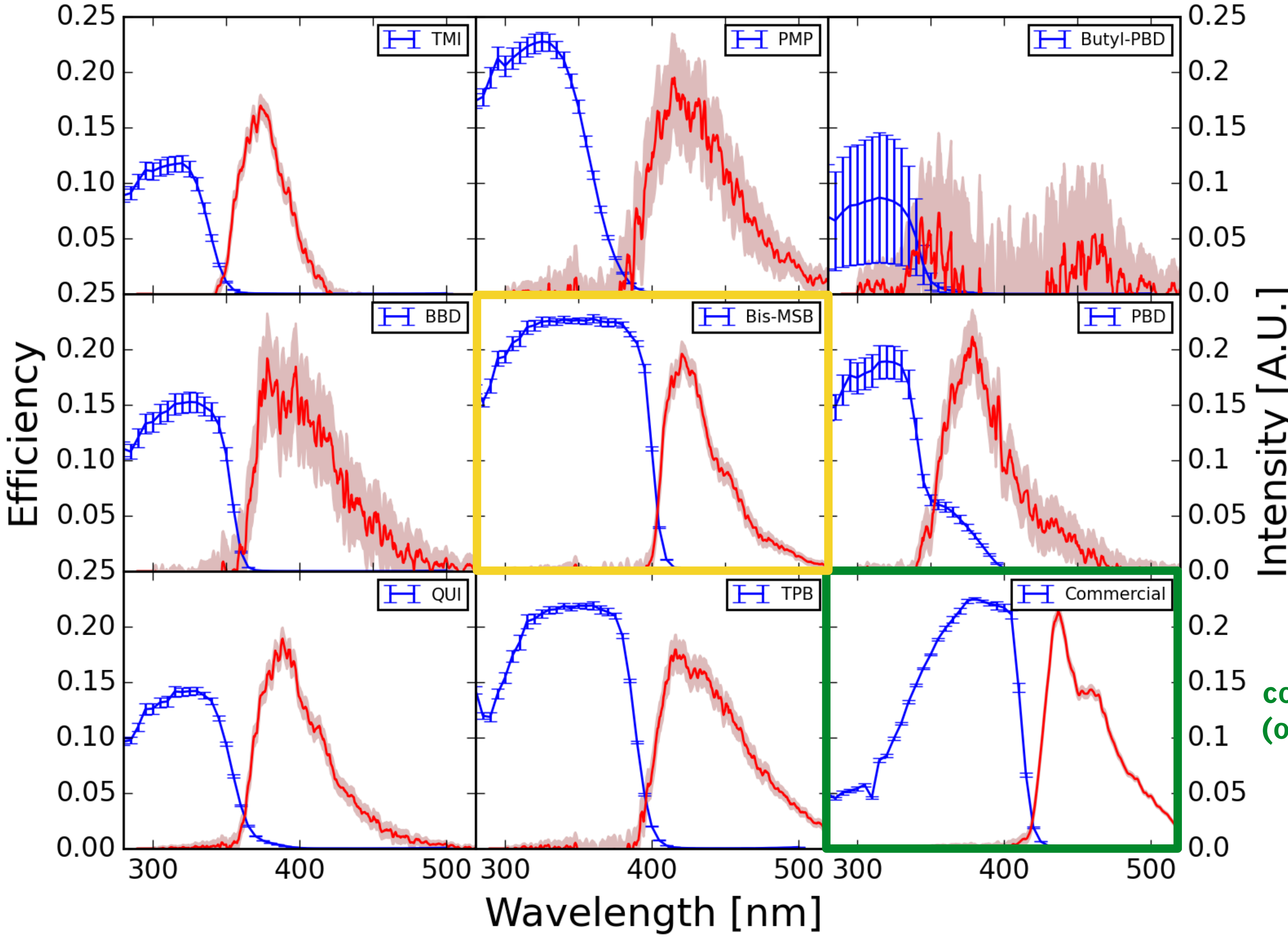
- Dichlormethane, Anisole, Tuolene, Xylene

Wavelength shifters

- p-Terphenyl
- Bis-MSB
- PMP
- TBP

Wavelength shifter efficiency

new best candidate



commercial (old) paint

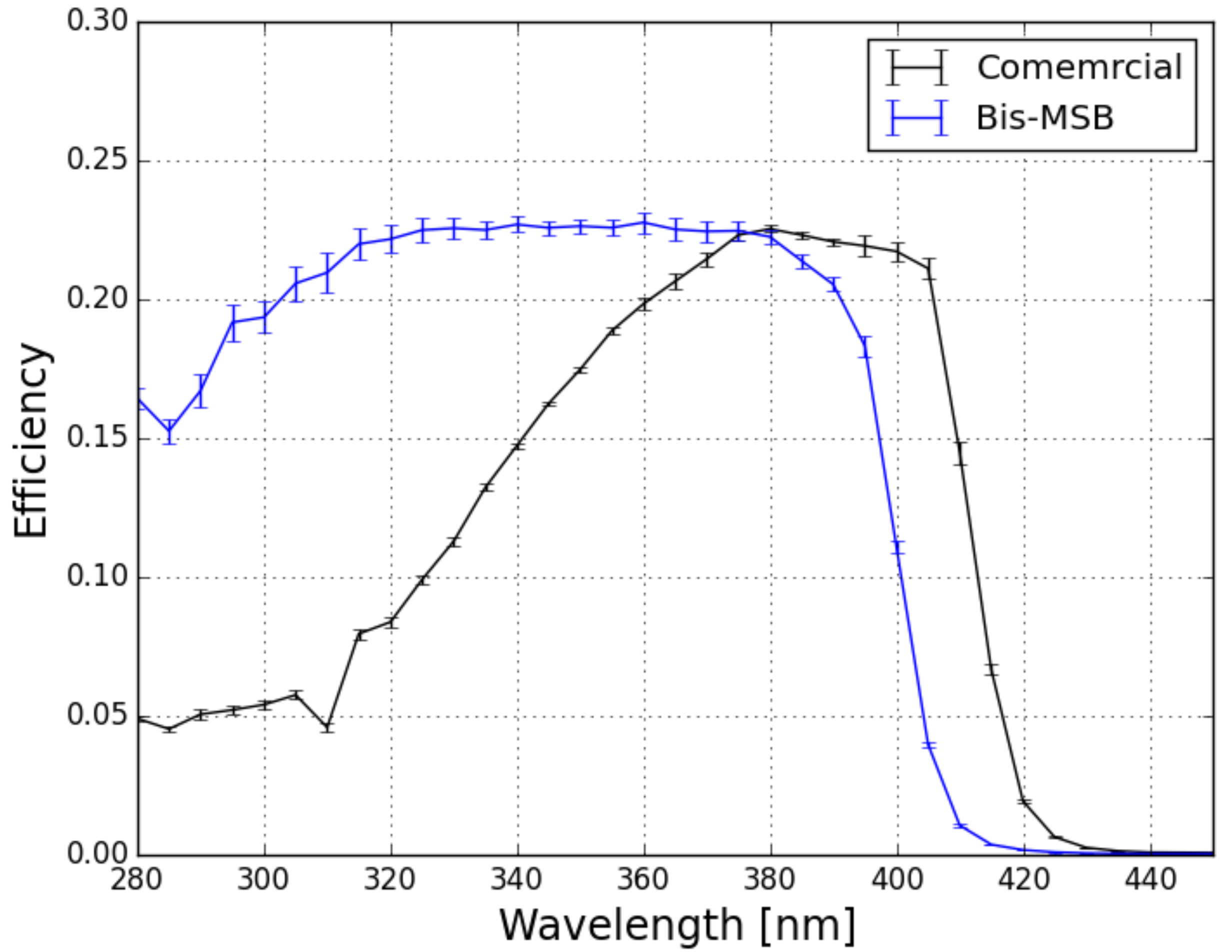
Paint selection

Best paint

- Bis-MSB
- PMMA
- Anisole

Performance

- large gain
  in UV region
- emission slightly
  more green



PRISMA

JG|U

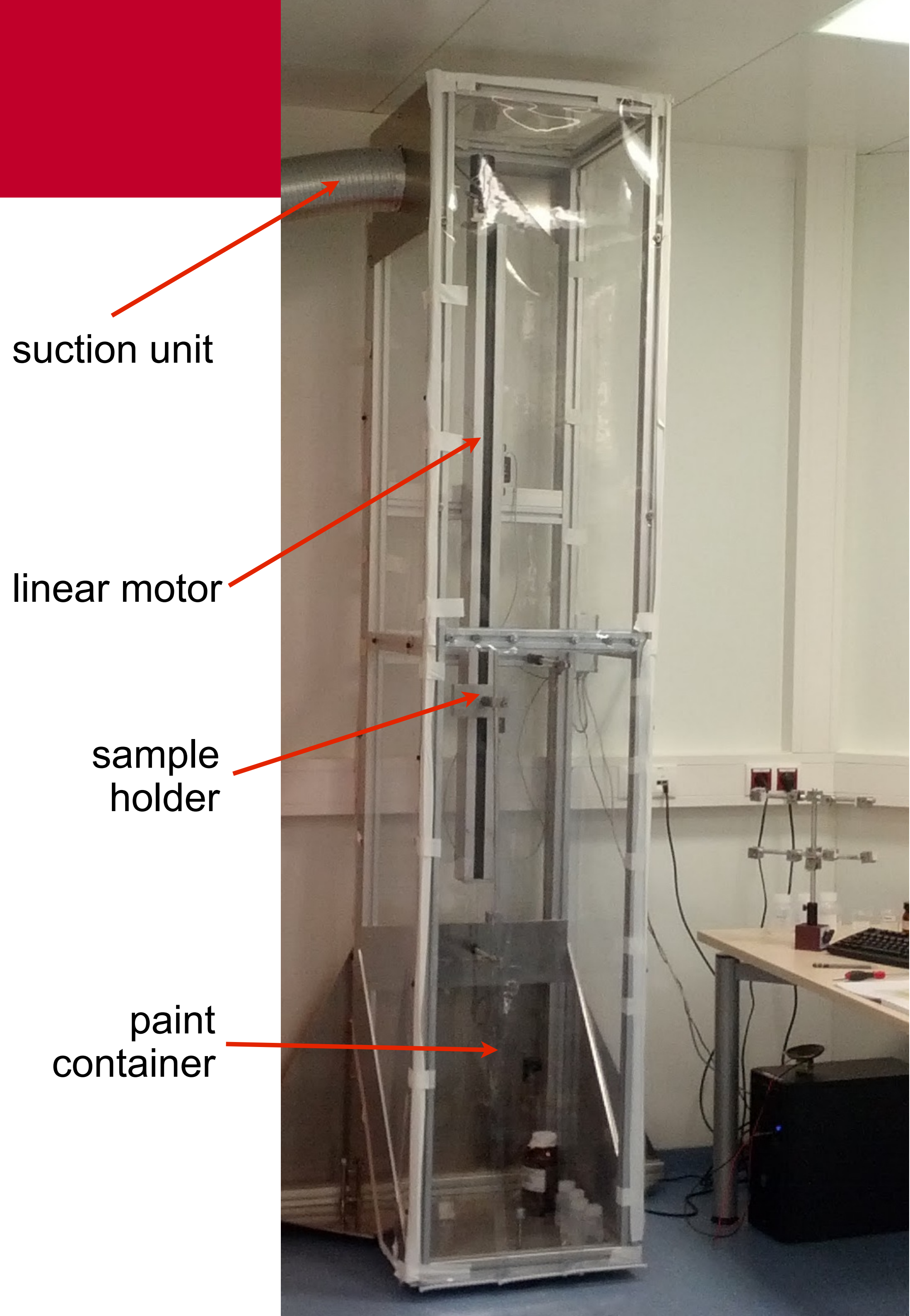
Painting

Dip coater

- leverage ~2m
- speed control
  - fully electronic
  - 0-10 cm/min

Setup

- clean room
  → minimal dust contamination
- suction unit
  → safety



PRiSMA

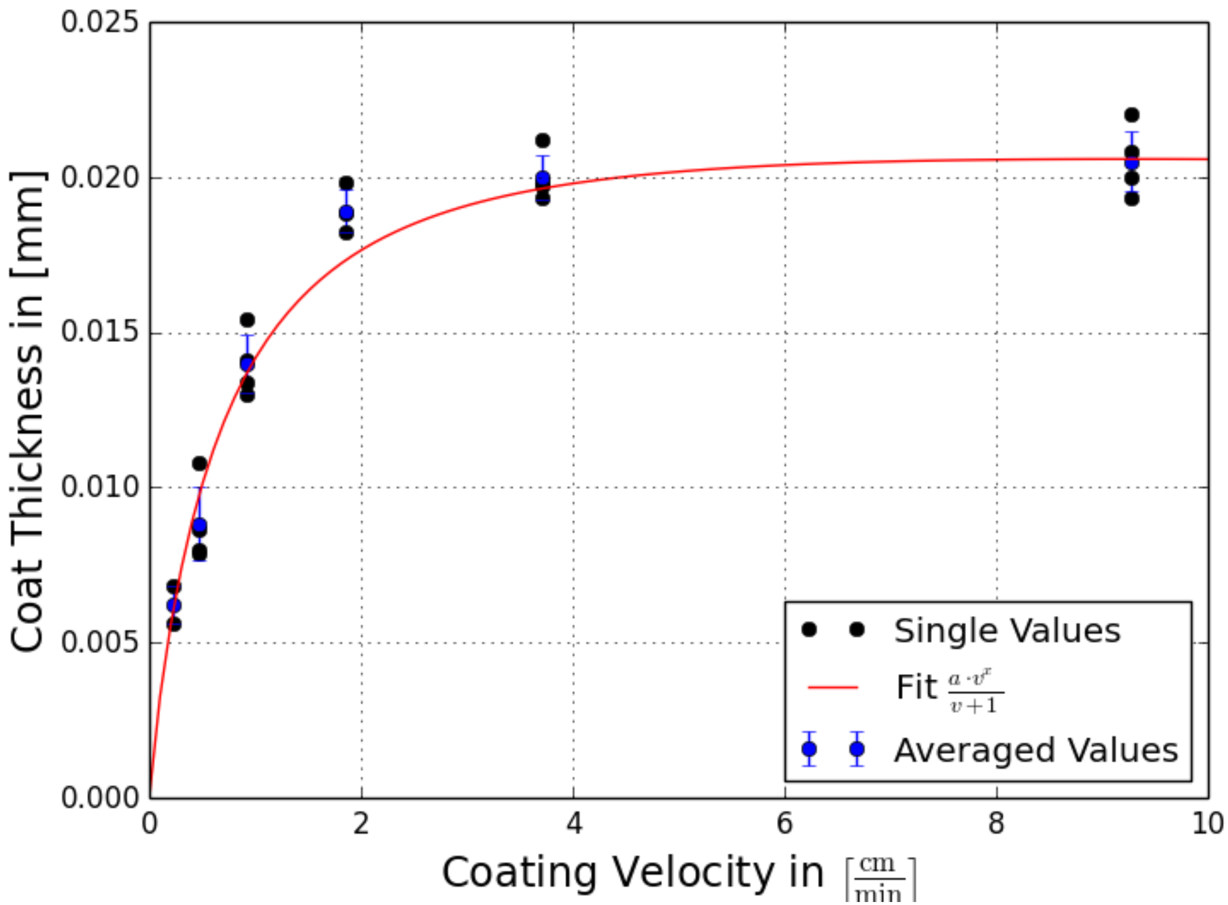
Dip coating

Dipping speed

- faster dipping
  → less time for paint to run off
  → thicker layer

Layer thickness

- weigh WLS layer
  → well reproducible

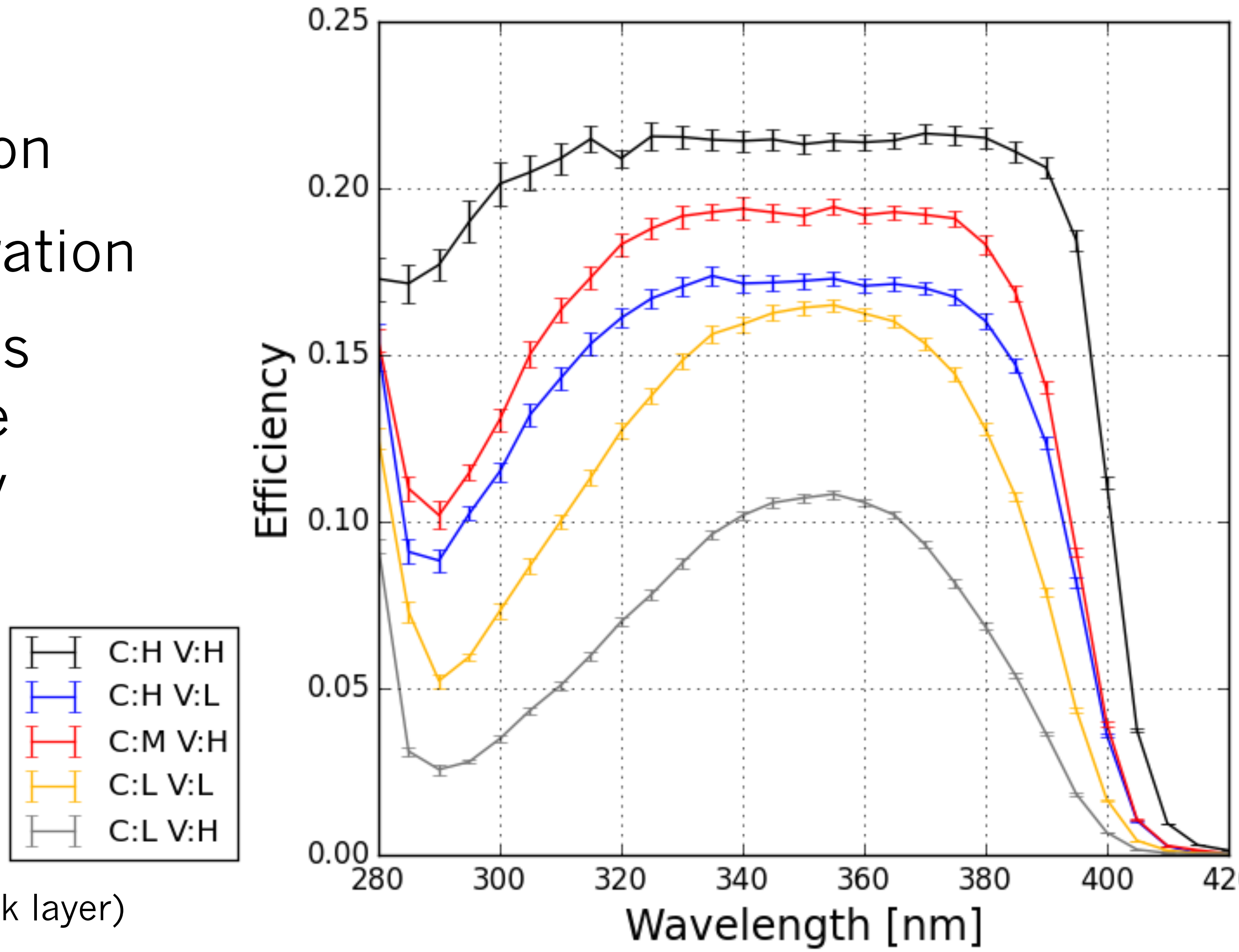


Optical thickness

Control absorption

- WLS concentration
- layer thickness
  ➔ maximize efficiency

C = Concentration
V = Velocity
H = High
M= Medium
L = Low



(high velocity = thick layer)

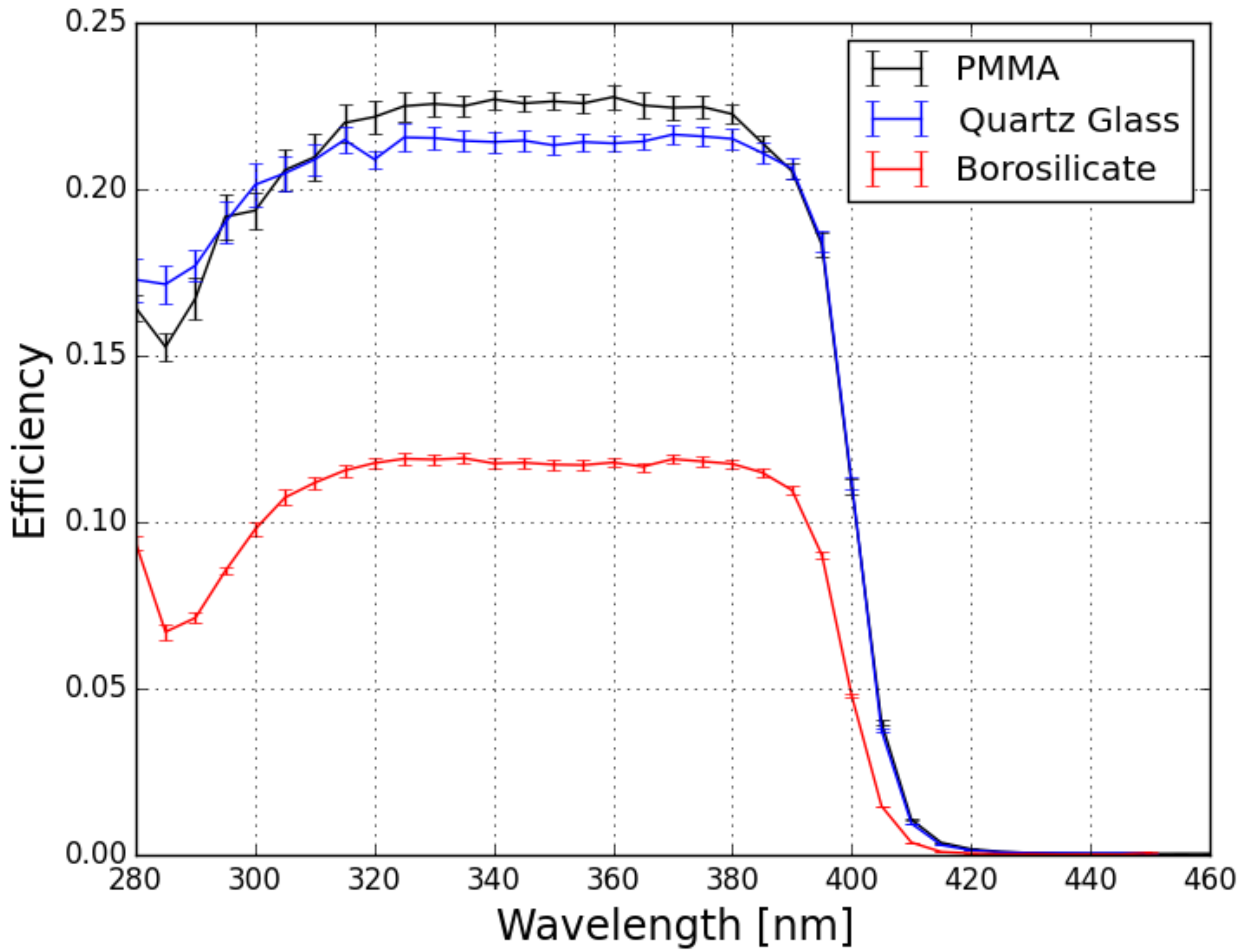
Substrate

Theoretical efficiency

- ε_{WLS} = 80-100% (?)
- ε_{TIR} = 74.6%
- $\varepsilon_{WLS} \cdot \varepsilon_{TIR} > 60\%$

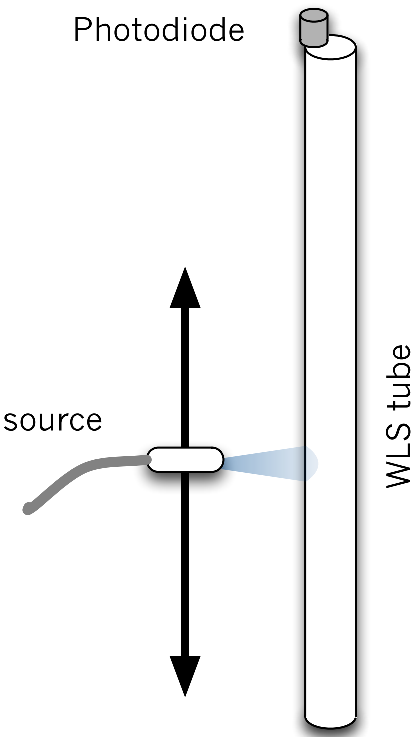
Sources of losses?

- Q.E. in plastic
- absorption
  - in WLS (reabsorption)
  - in substrate



Absorption

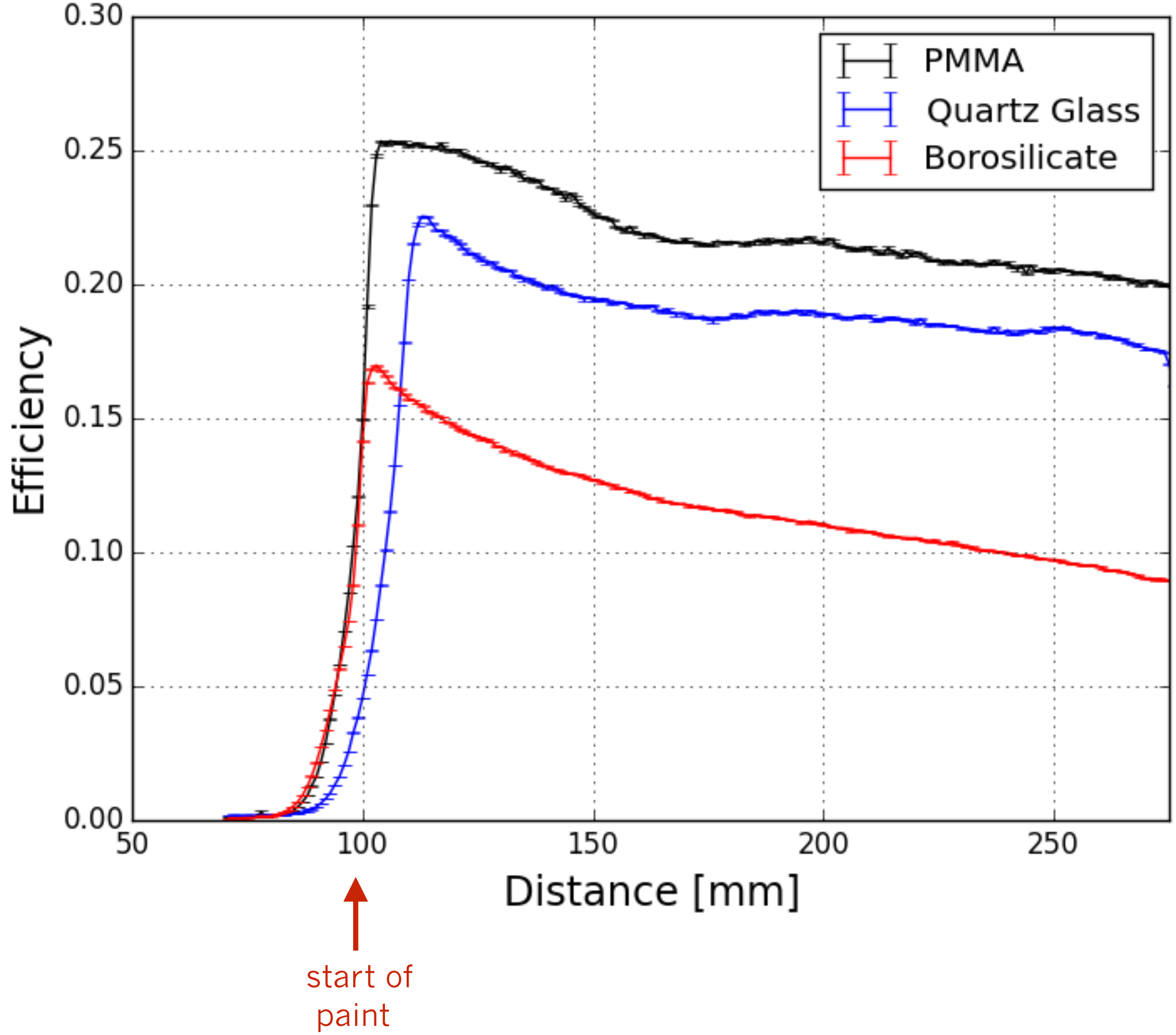
Setup



- geometrical correction applied

Absorption

- what is the source?



(Re-)absorption test

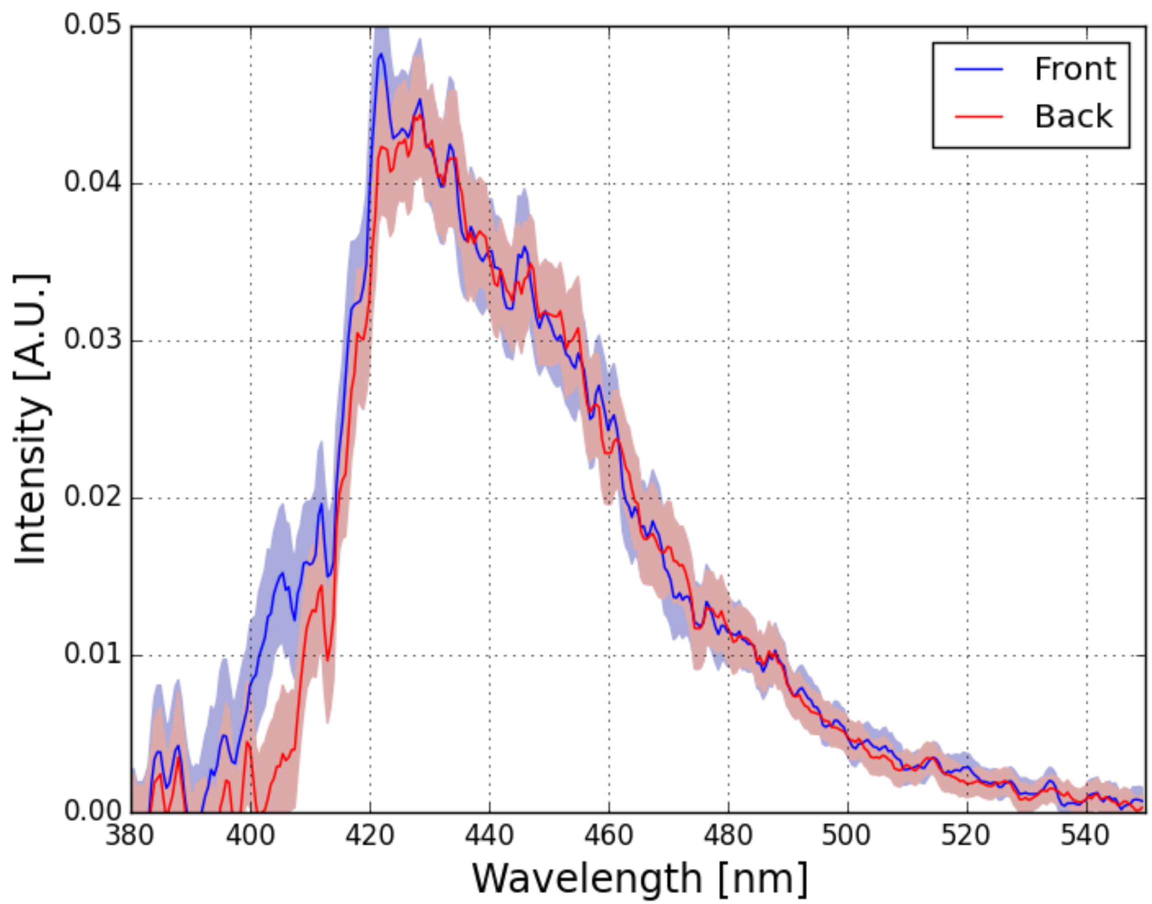
Idea

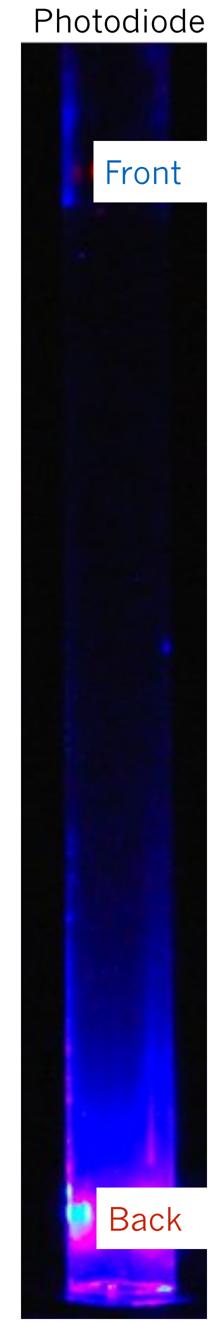
- shifted light is reabsorbed
- re-emission ➔ likely lost

Emission

- visible in photographs
- spectrum indicates small effect

➔ is the light scattered?

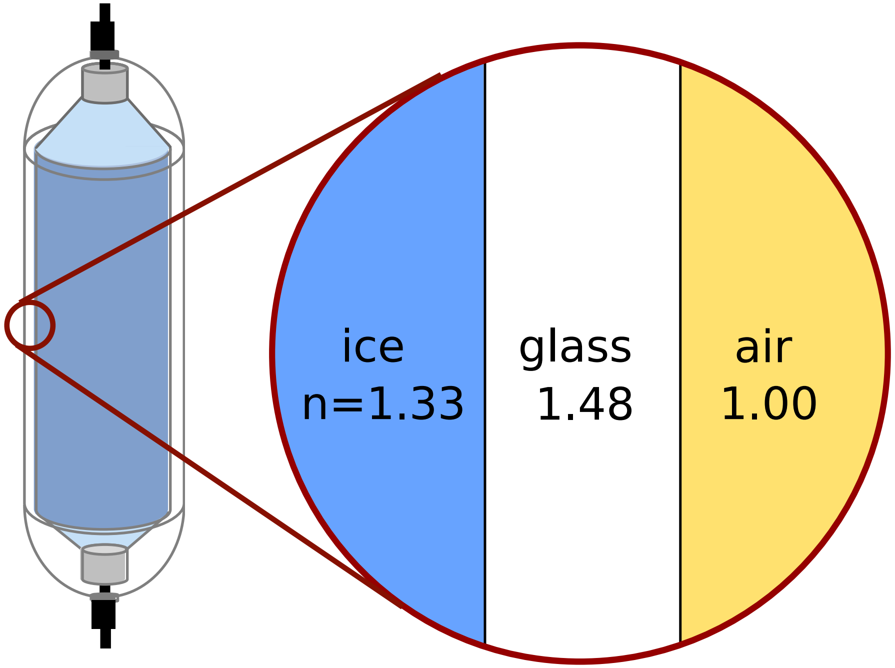


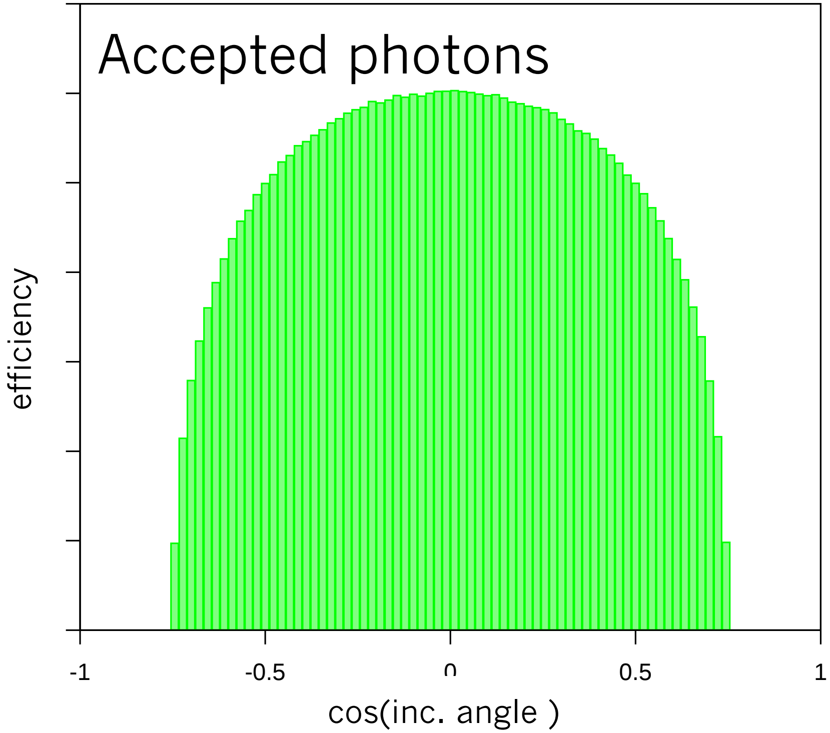


Maximizing Liouville

Liouville theorem

- Entendue (aperture · solid angle) is constant
- (Only) detect photons that enter the WOM

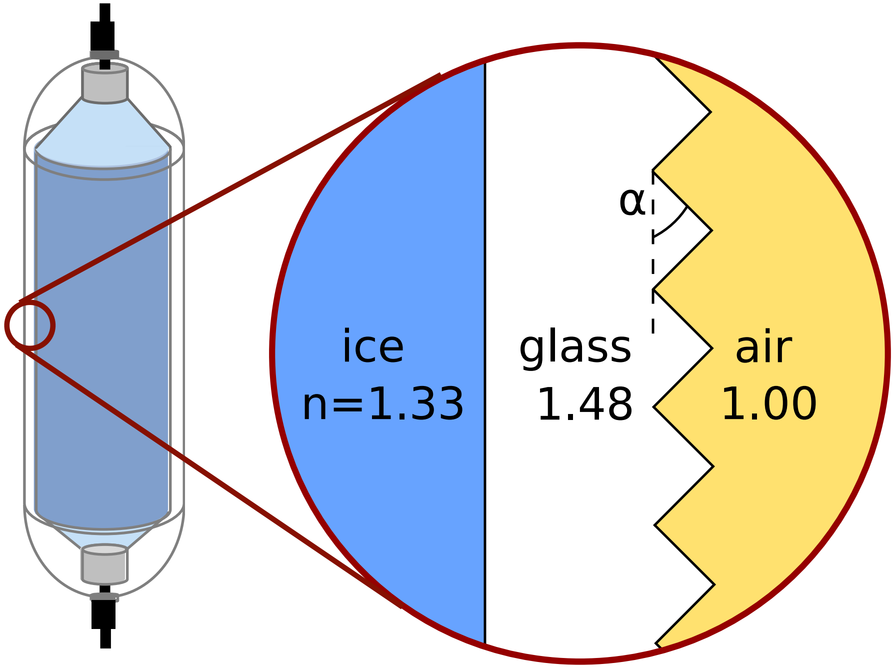


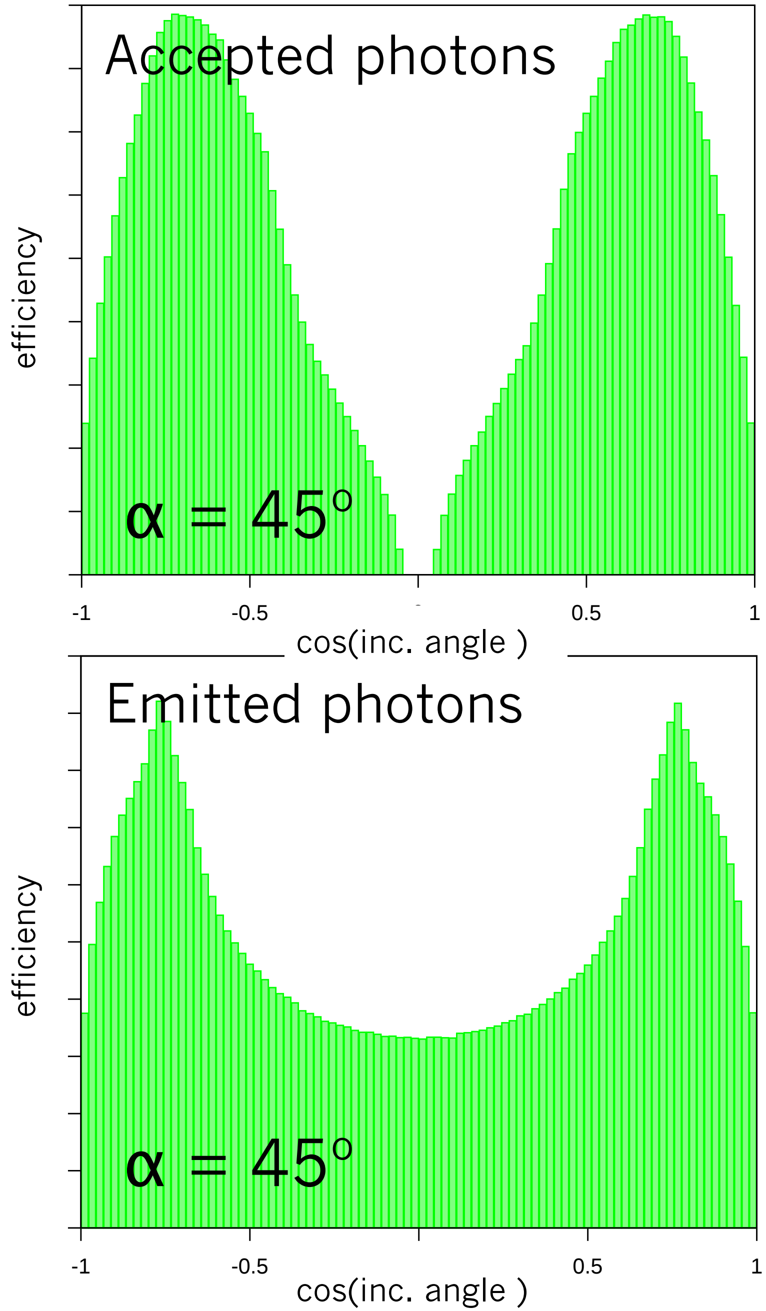


Maximizing Liouville

Triangular surface grid

- check performance with ray-tracing code
- optimal angle $\alpha = 45^o$





PRISMA

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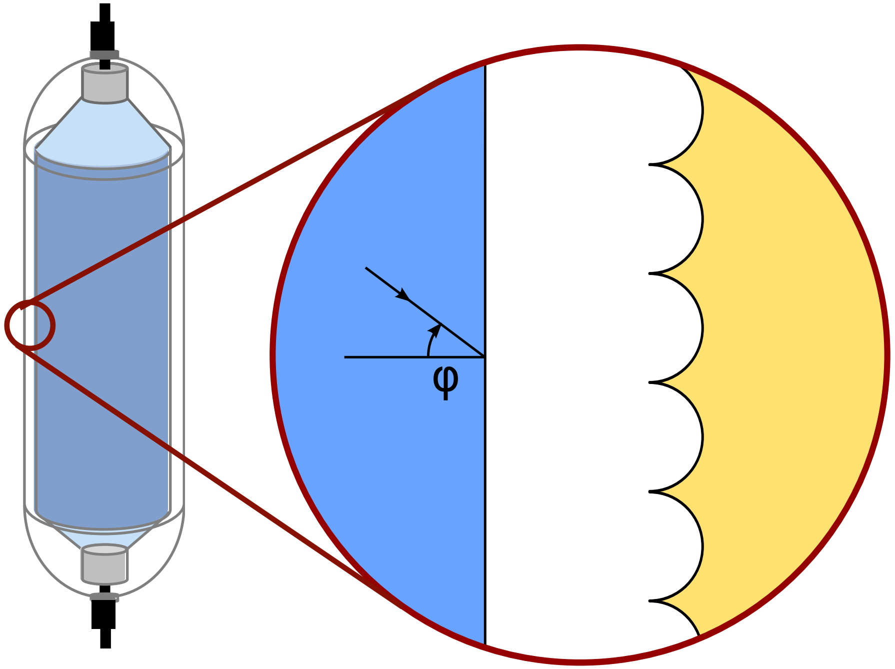
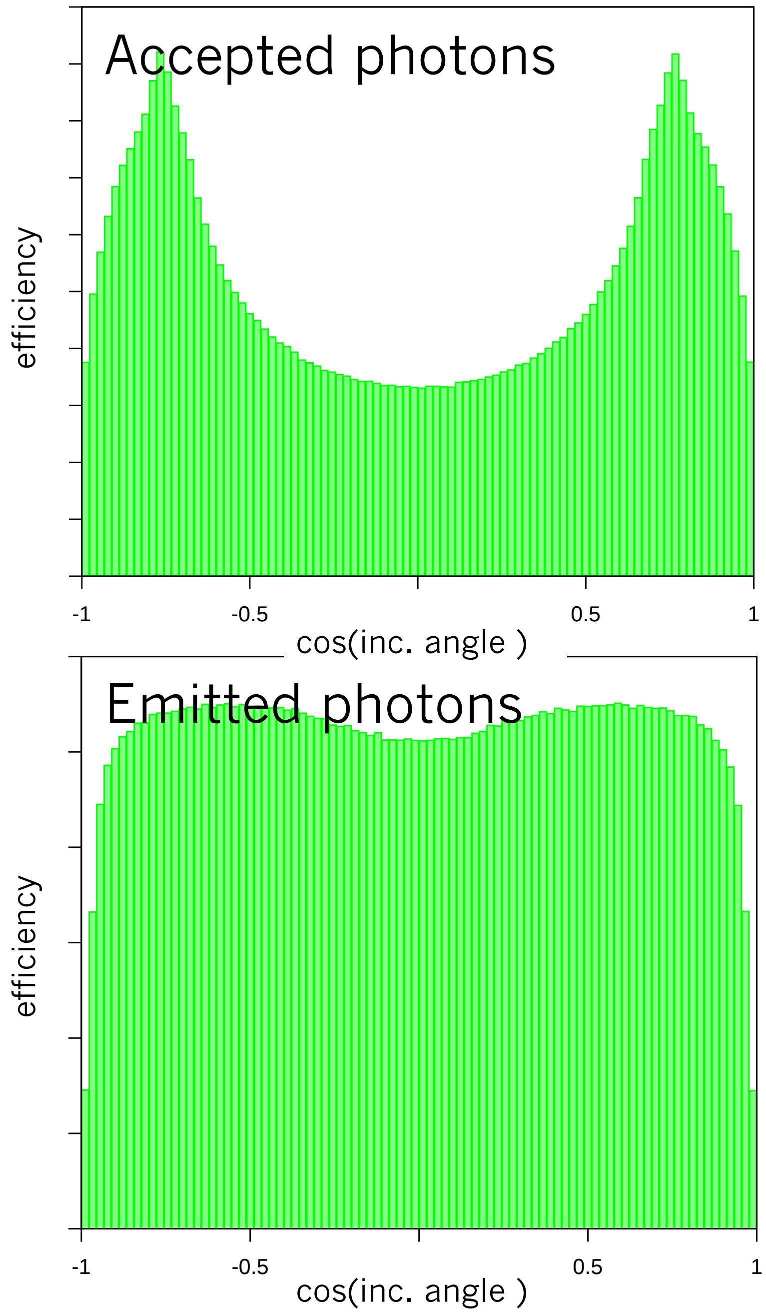
Maximizing Liouville

Semi-spherical surface grid
(lenticular arrays)

- maximizes acceptance
- gain **37%** w.r.t. flat





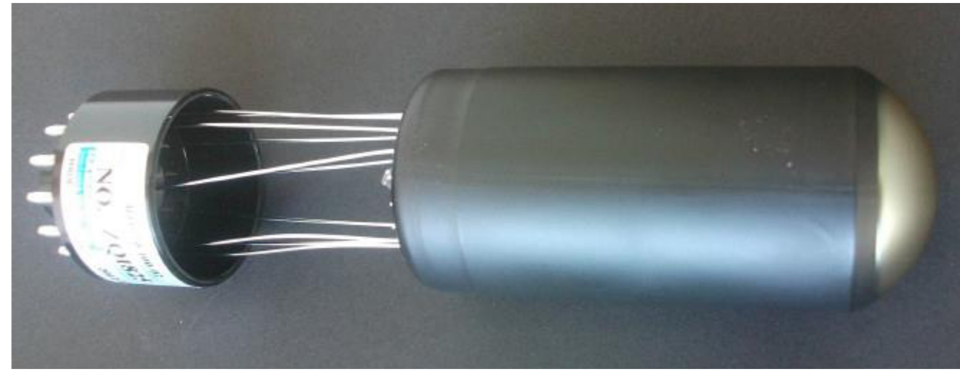
Choice of PMT

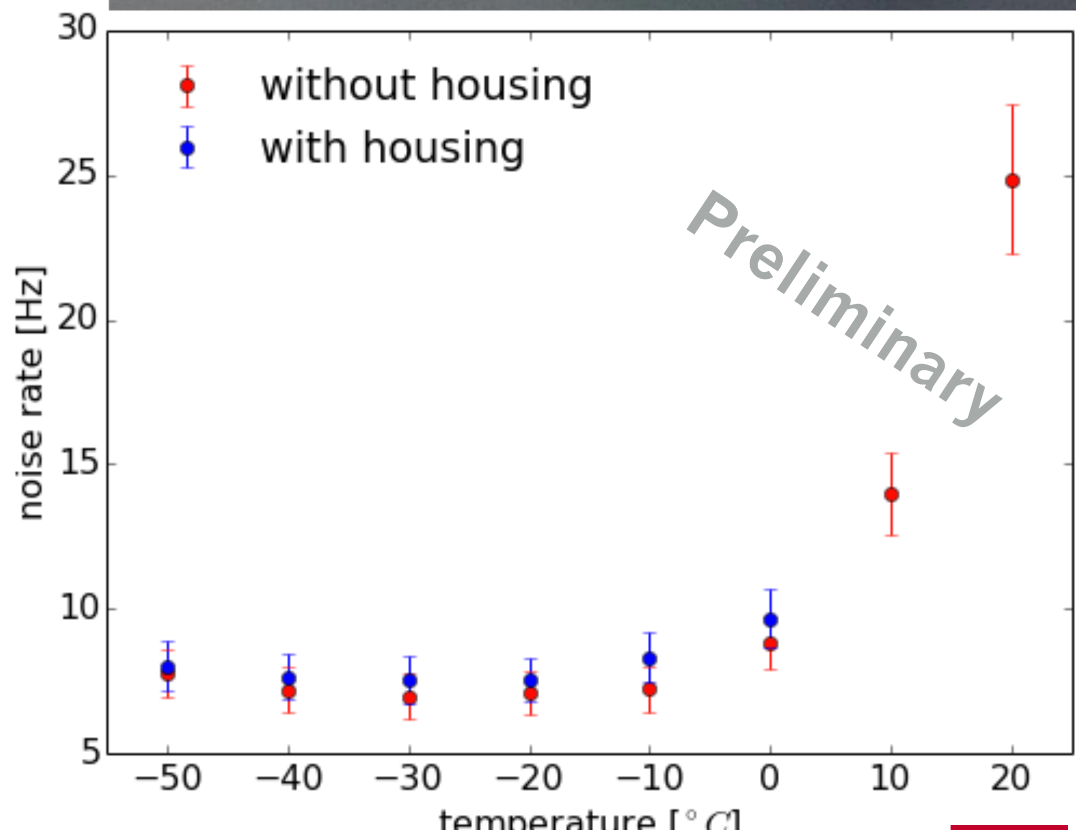
Hamamatsu R11920-100

- high QE (32-35%350nm)
- low noise
- 8 dynodes ➔ low gain

Freezer test

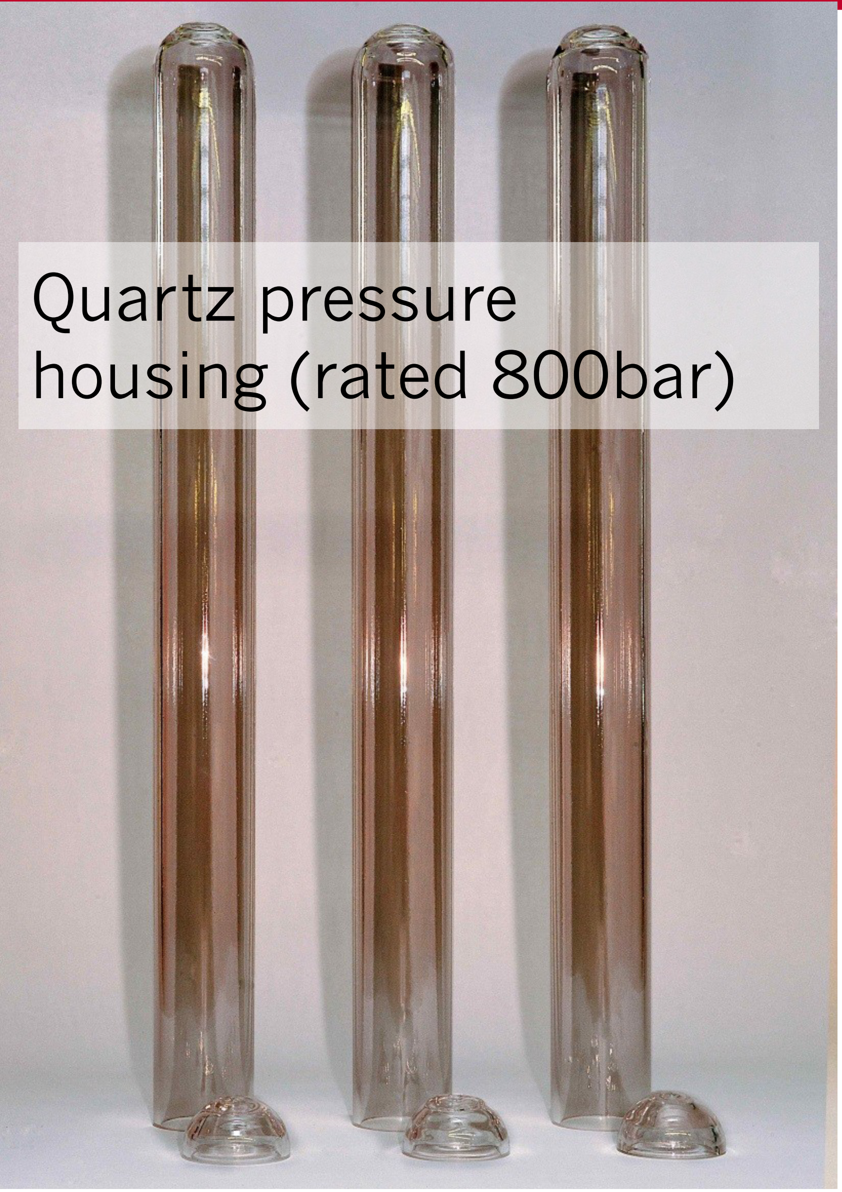
- measure noise @ 0.25pe
  ➔ reach < 10Hz
- small impact
  of glass housing





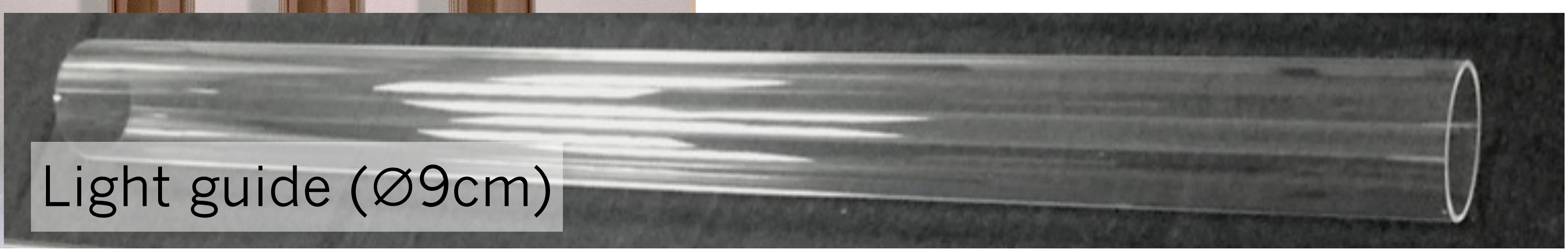
Prototype development

Prototype development



Quartz pressure housing (rated 800bar)

Prototype development



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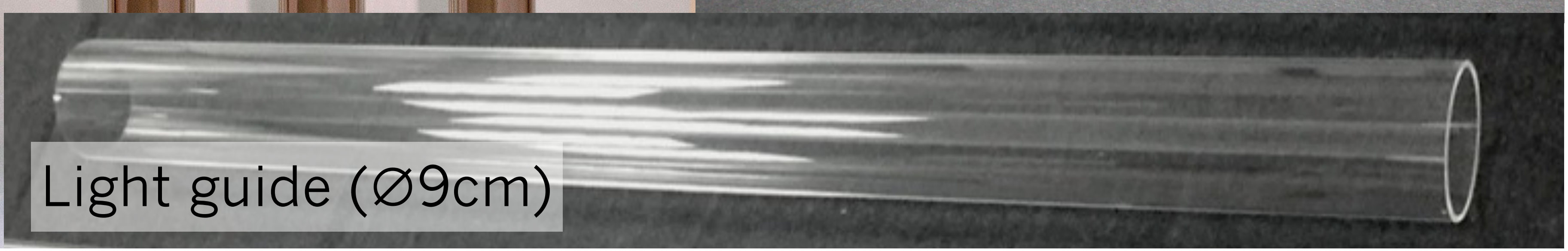

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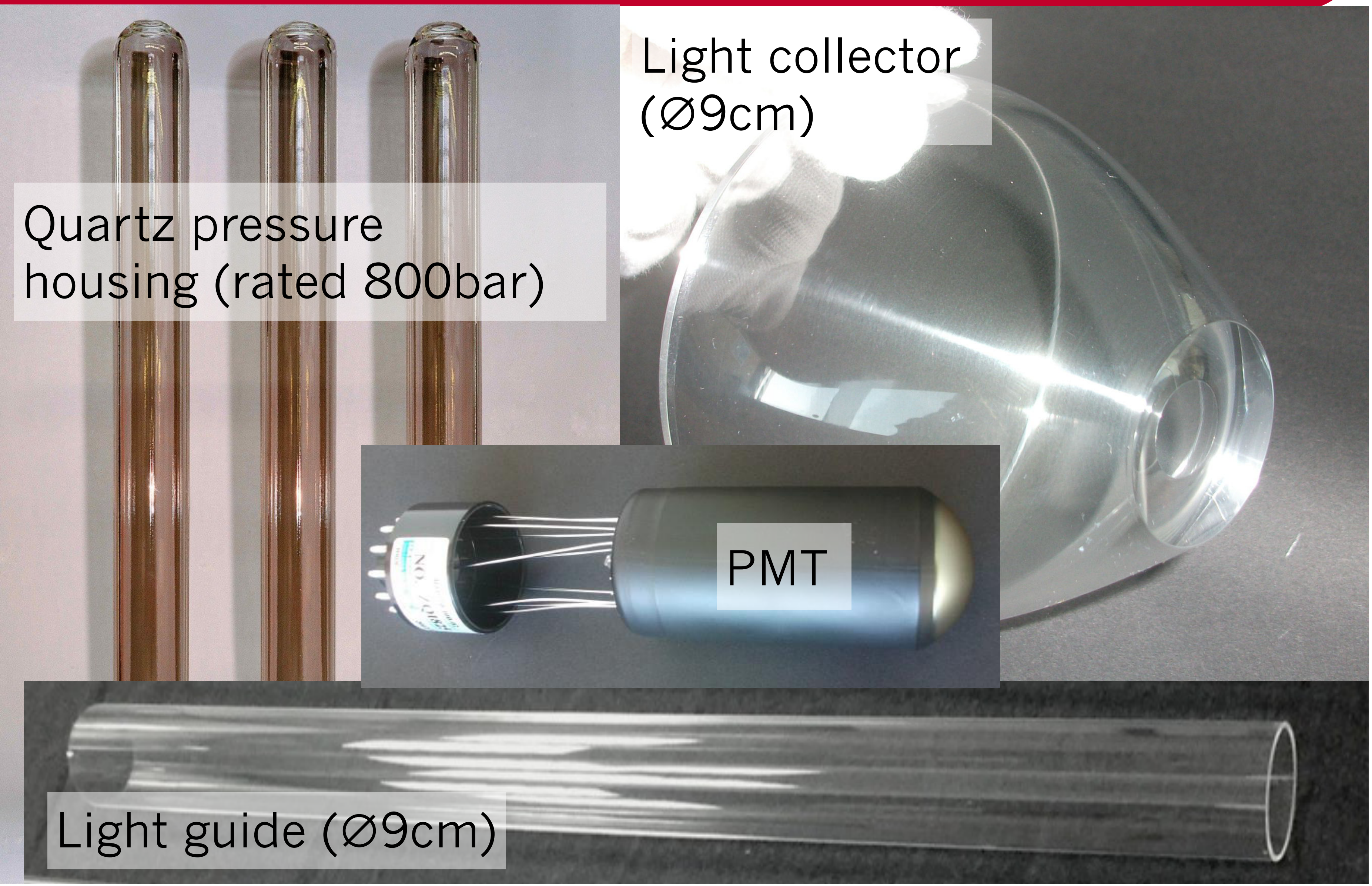

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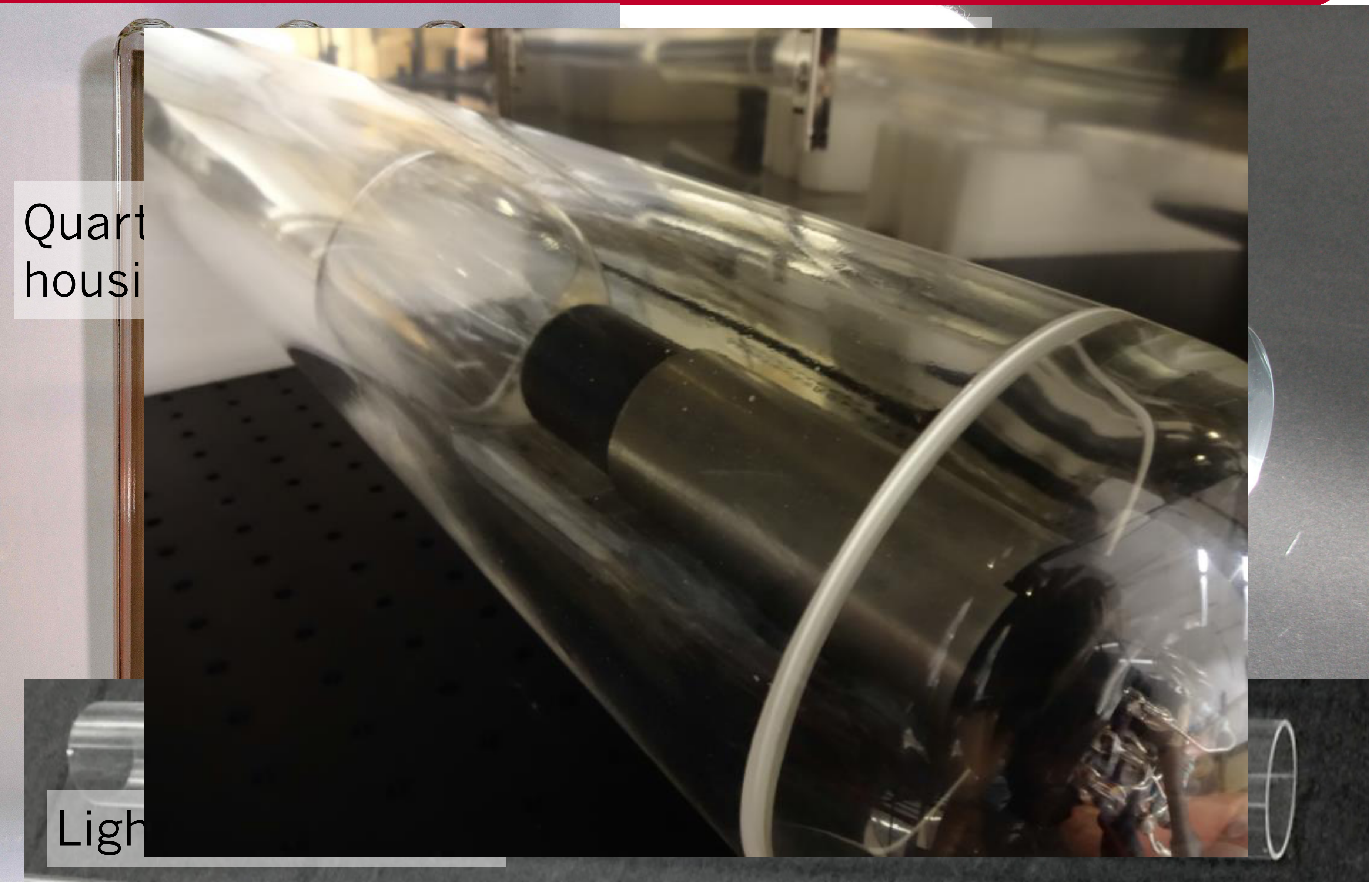

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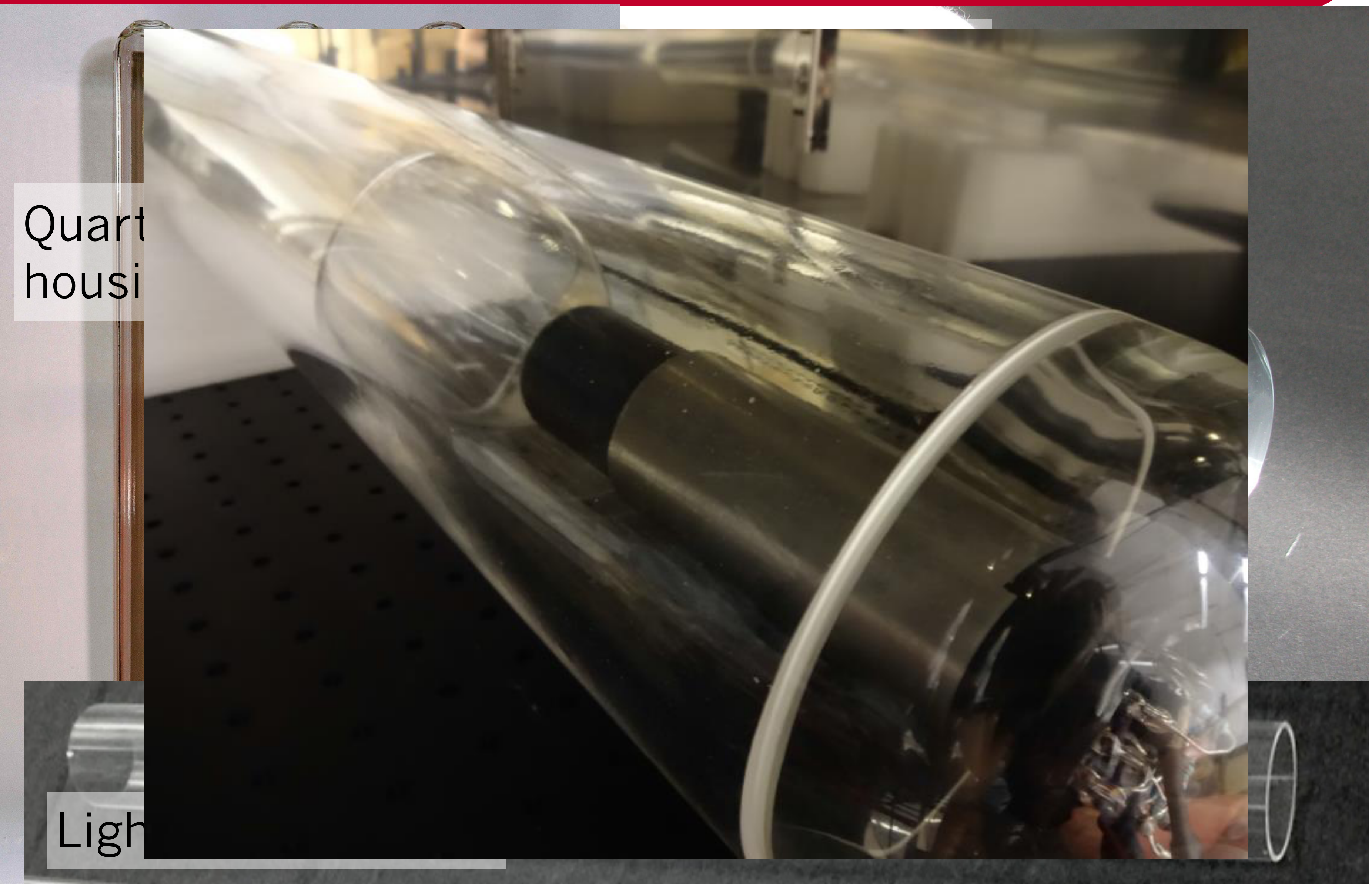

Summary

- Wavelength shifting Optical Module
  - ➔ High effective area at low noise
- Optimizing WLS and light guiding
  - ➔ Significant gain with home-mixed paints
  - ➔ (Re-) absorption in transport?
  - ➔ Lenticular arrays can increase acceptance
- Selection of PMT
  - ➔ 10Hz noise level seems reachable