Design and studies of a new optical module for IceCube high energy extension

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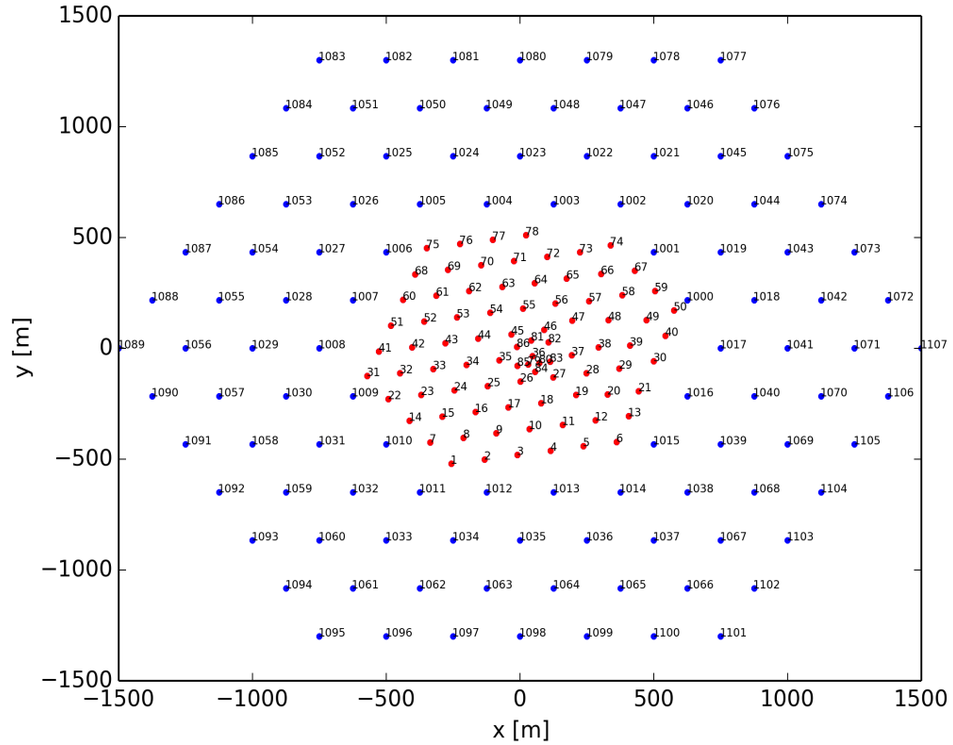
presented by Romain Gaior

Introduction

C. Haak IC collab. metting Geneva

High energy extension

- Volume ~ 10x IceCube
- Geometry not yet defined
- Larger spacing



Example of HEX geomettry

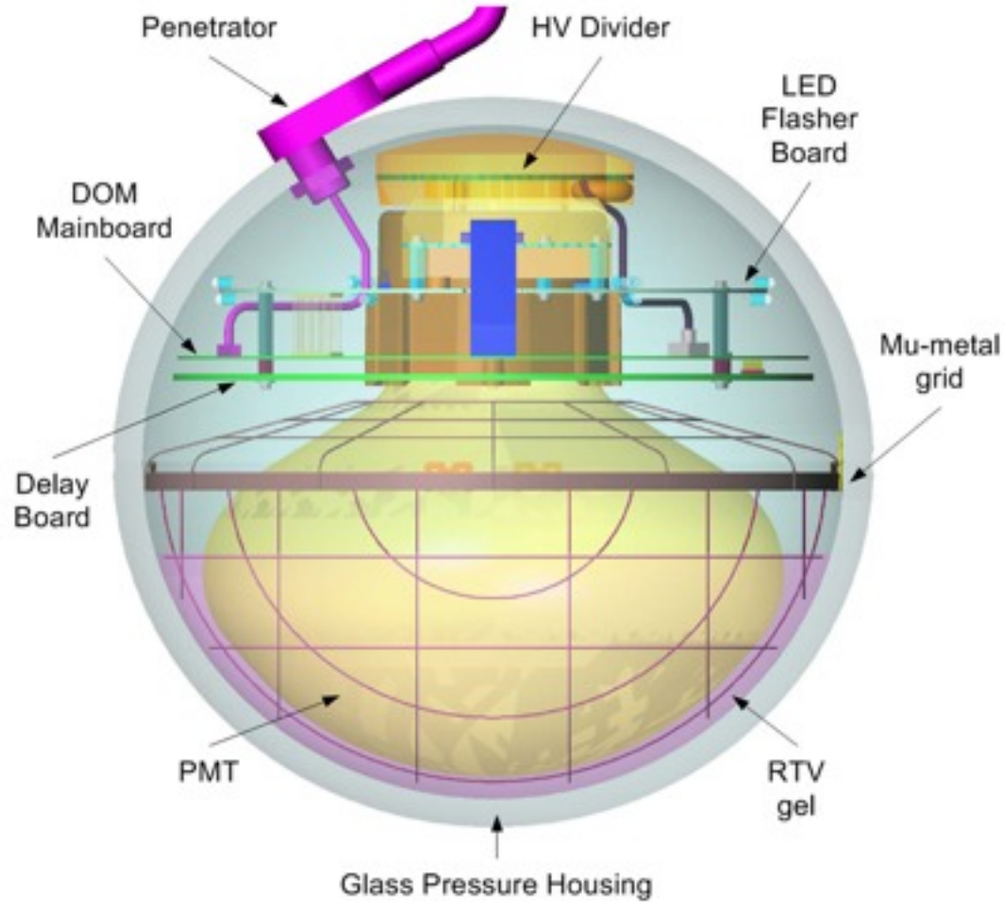
Instrumental constraints

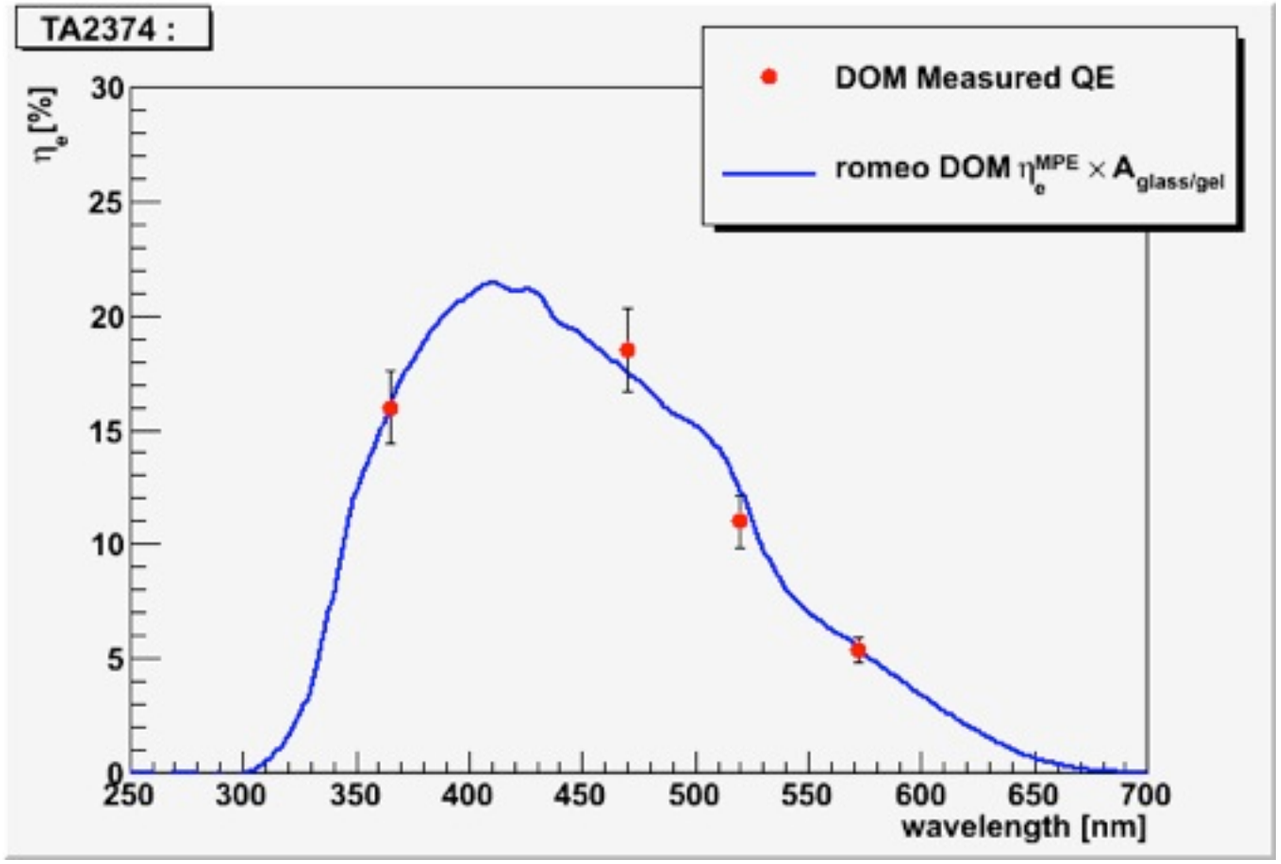
- ~6000 modules→cost effective
- Larger spacing→ need better photon collection

- drilling cost
- Pressure resistance
- Temperature

From IC DOM to New DOM

IceCube DOM



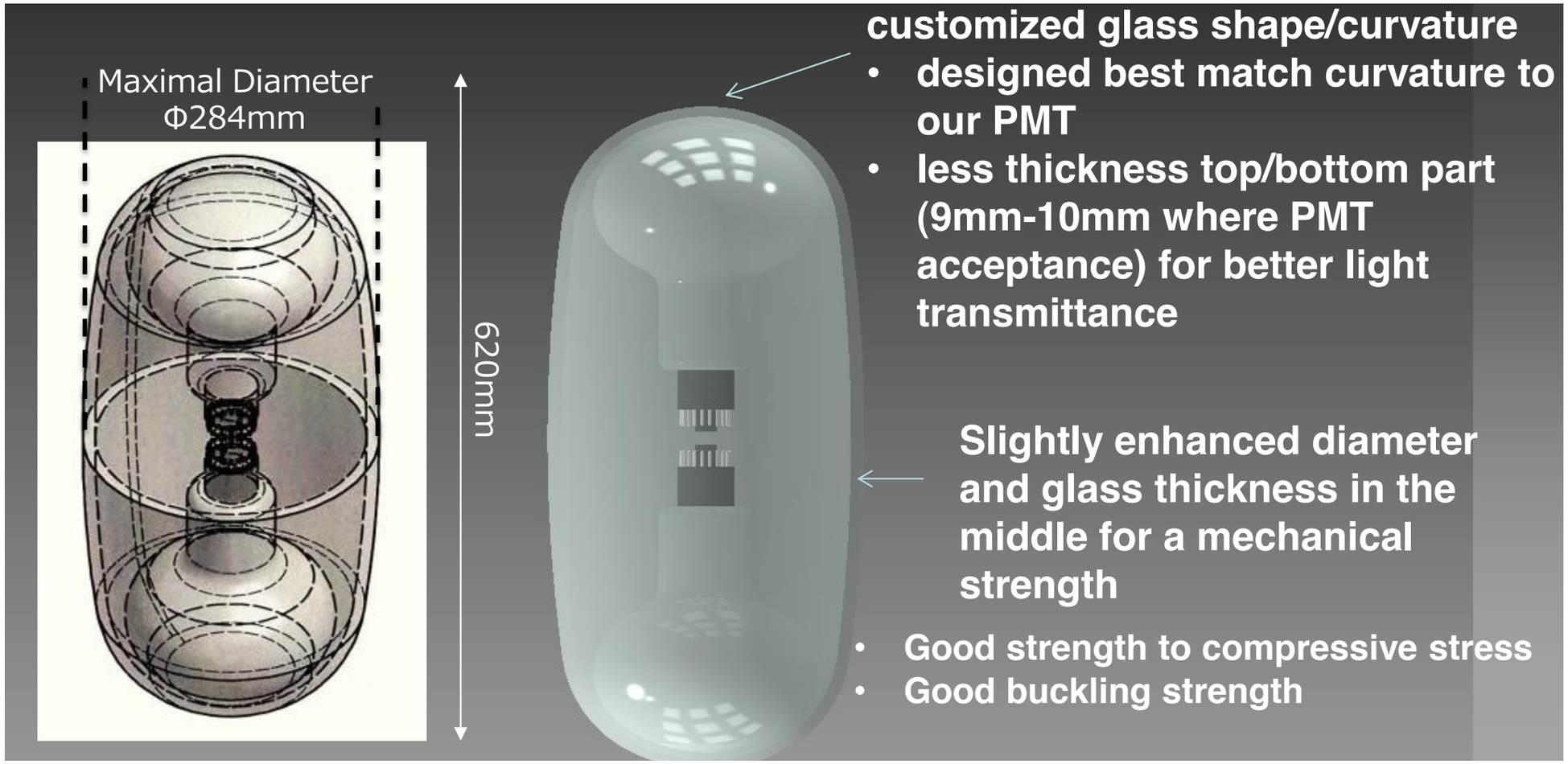


- 10 inches PMT
- Spherical glass housing

- Good QE at ~400nm
- ~5-10% at 350nm

From IC DOM to NewDOM

Concept: two 8’ PMT back to back in a elliptical glass house



- **2 PMTs back to back**: up/down symmetry for **veto, reconstruction**

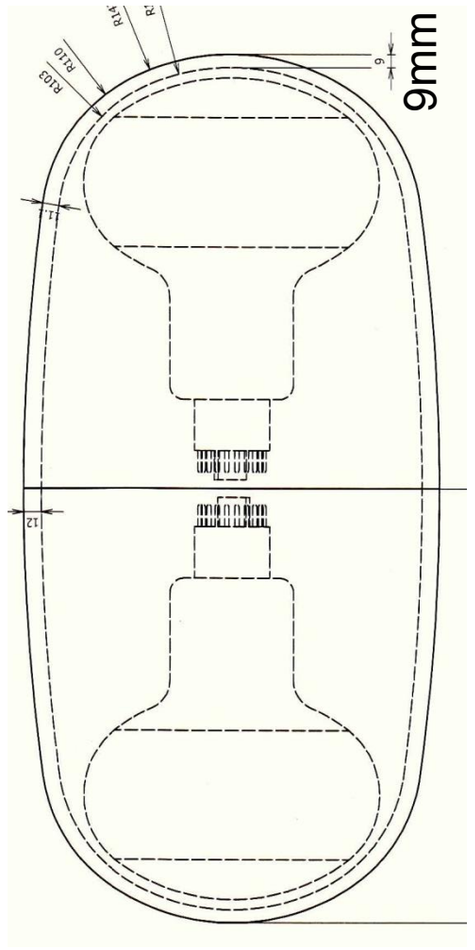
- **2 PMTs** instead of 1: **better saturation response**

- **Ellipsoidal** glass shape: customed for PMT curvature and **smaller diameter**

- **Simple design**: close to IceCube design

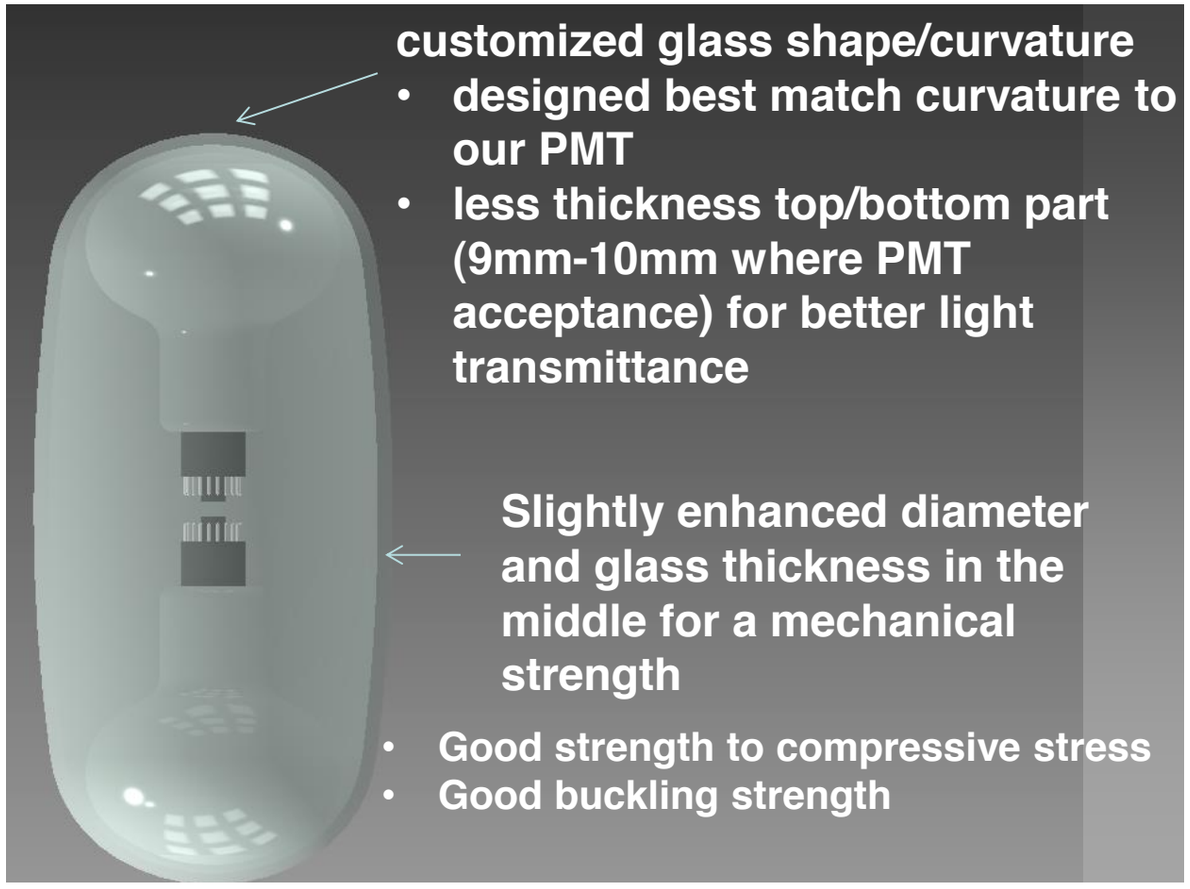
Photon Detector

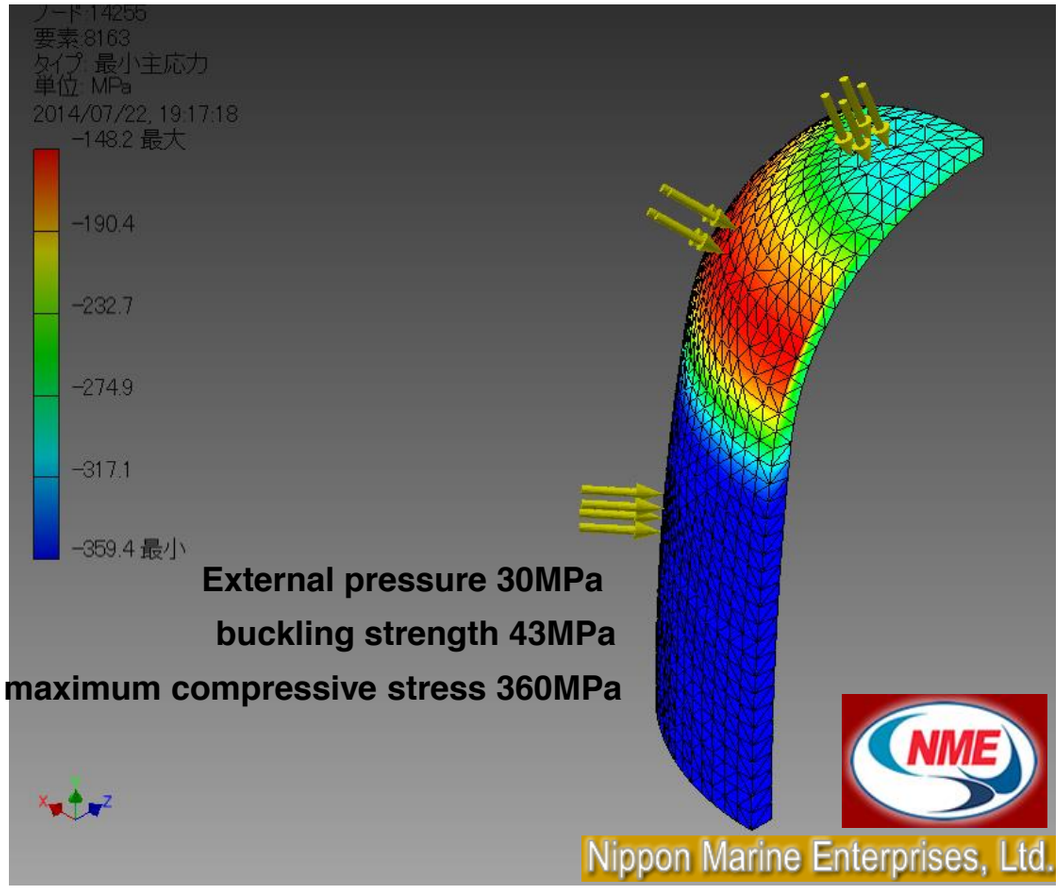
Hamamatsu 8’ PMT



- Two 8’ Hamamatsu R5912 High-QE
- Close relations with Hamamatsu
- Considering also an Hybrid Photon Detector (already ordered to test)

Glass design

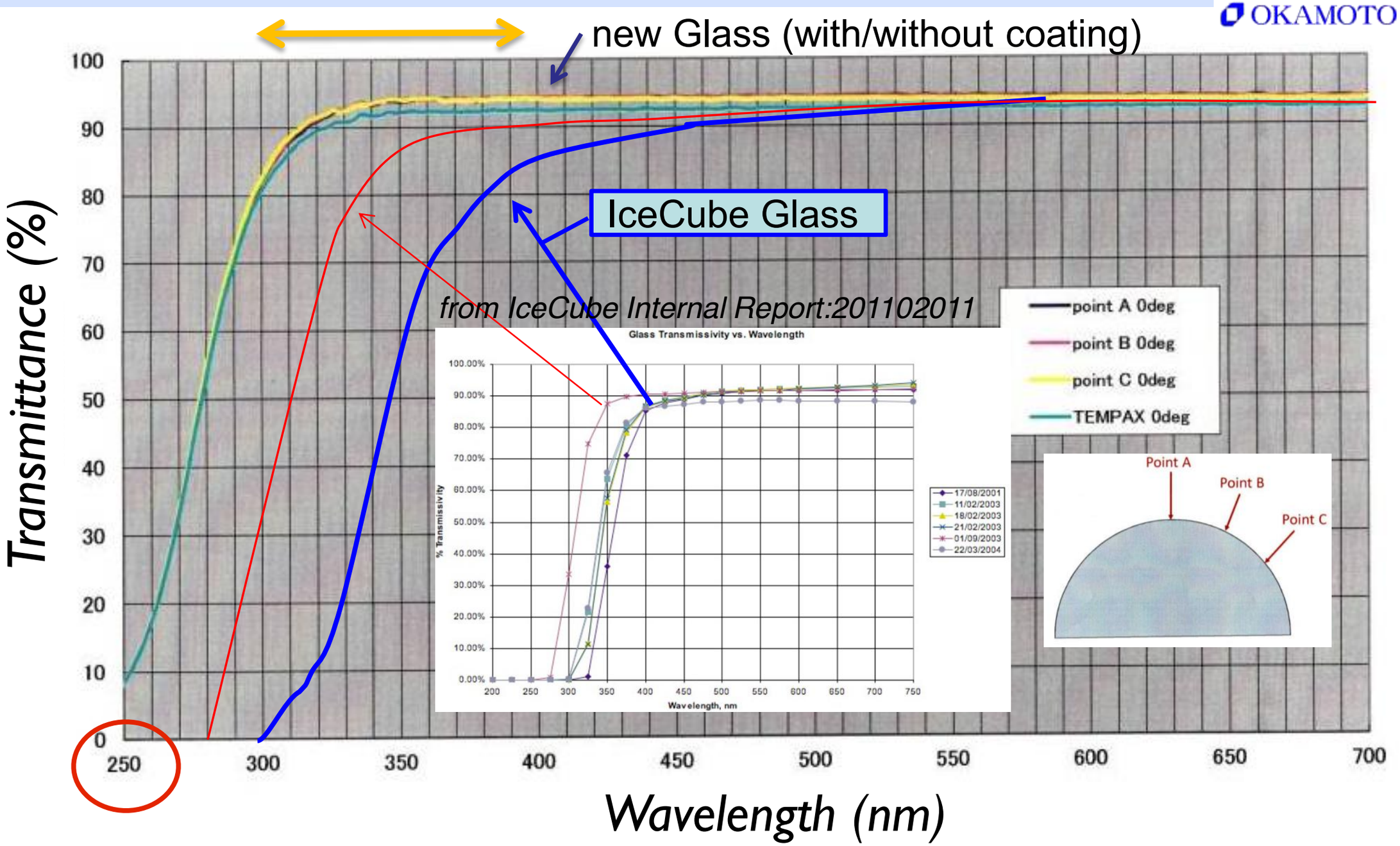




- Matched curvature glass/PM
- Optimized glass thickness for transmittance/resistance
- Total diameter 284mm
- Pressure simulation OK for ~350bar

Glass Transmittance

OKAMOTO GLASS



Large improvement down to 250 nm

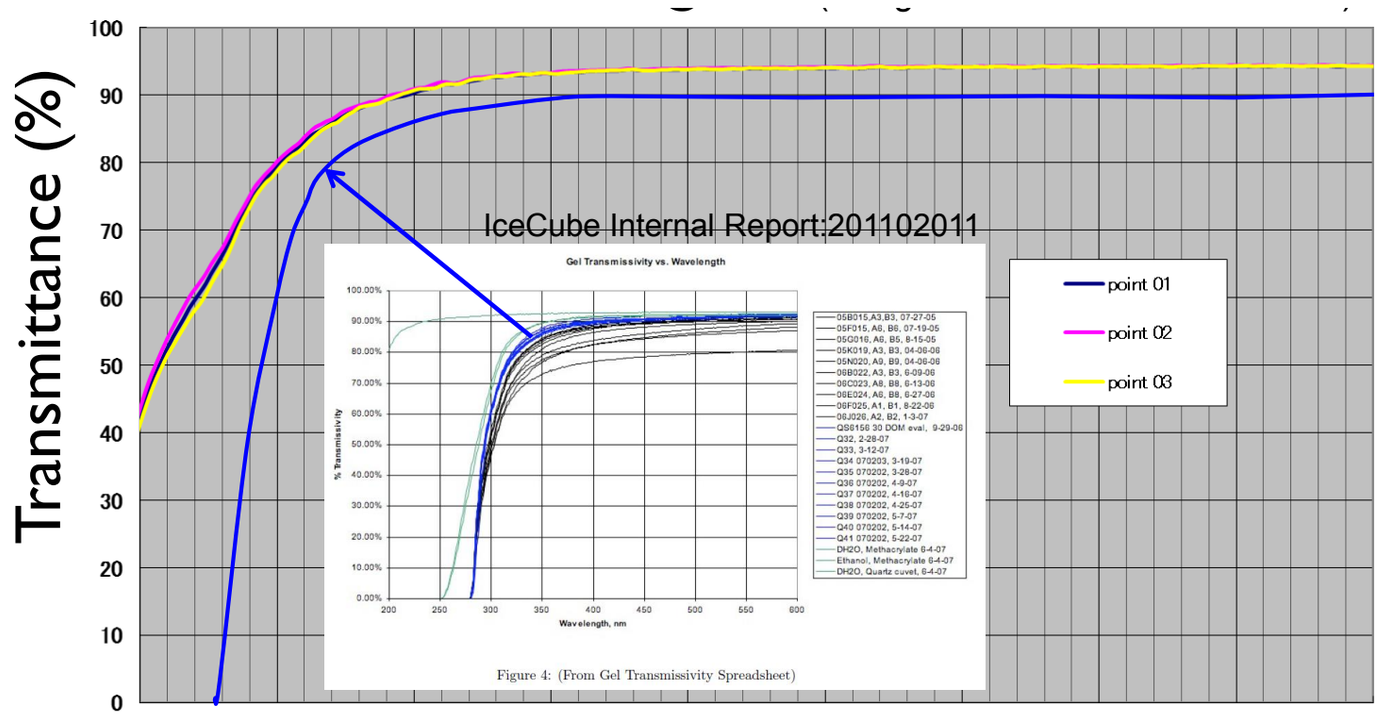
(Cherenkov spectrum $\propto 1/\lambda^2$)

Additional coating improves another 2-4%

Gel Transmittance

OKAMOTO GLASS

Gel sample



New gel: *Shinsetsu Silicone*

Easy to treat and shape

Transmittance improved at all λ

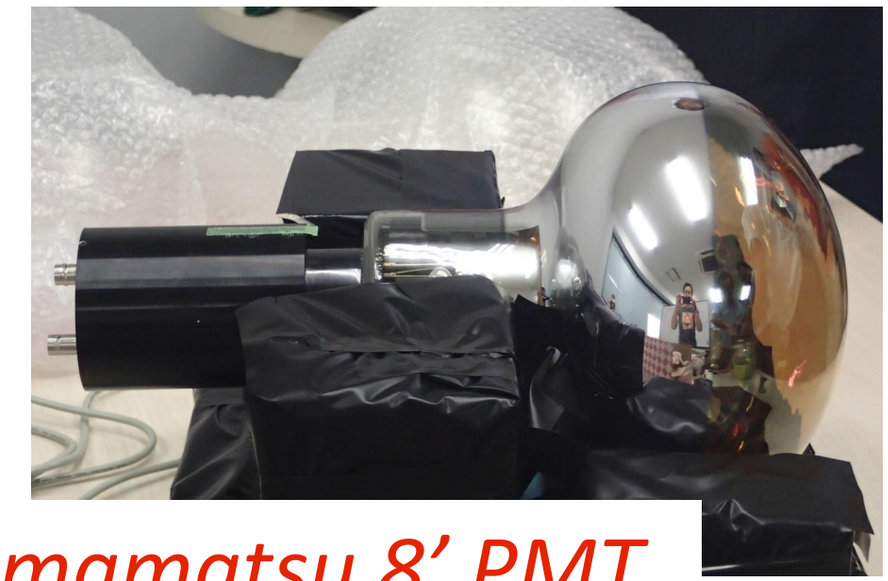
Larger improvement at small λ (< 300nm)

→ *still needs test at low temp*

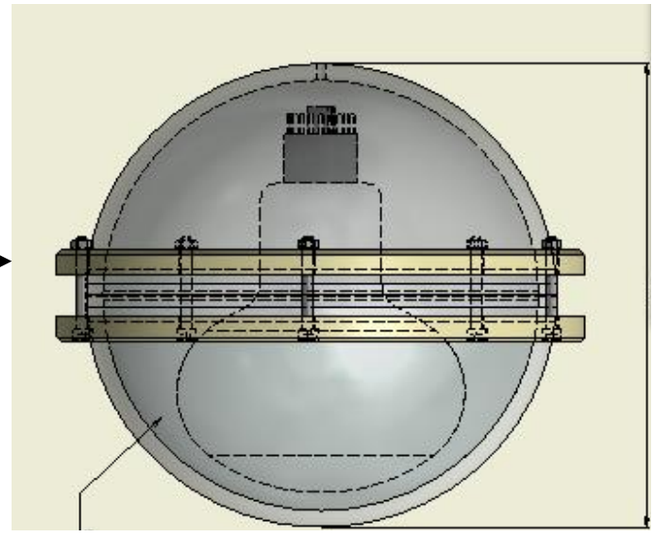
First tests and measurements (a few pics)

All credits Hans Niederhausen (Stony Brooks Uni.)

First tests with spherical glass for practical reason



Hamamatsu 8’ PMT



Design

Realisation

First tests and measurements (setup)

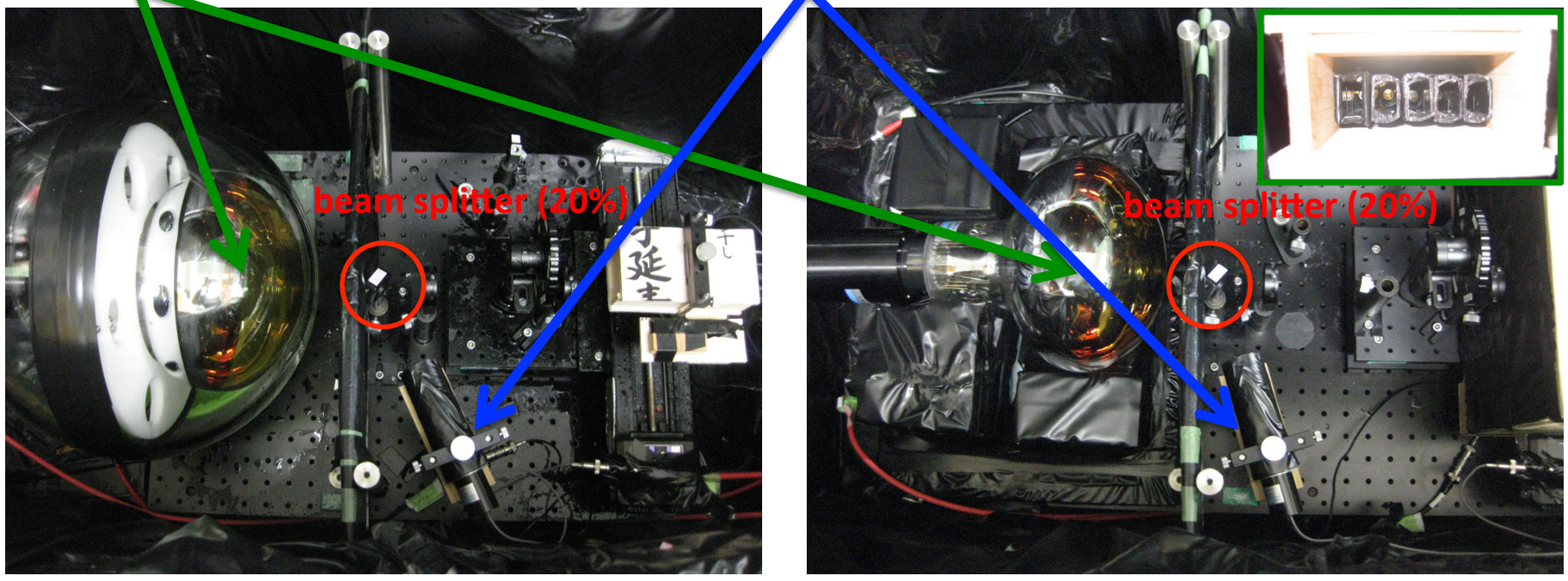
All credits Hans Niederhausen (Stony Brooks Uni.)

Measurement of absolute Quantum Efficiency

$$Q_{pC} = g < Q >_{spe} q_{eff} N_{phot} e$$

"big" PMT

"small" PMT



Absolute Calibration using a calibrated PMT as ref.

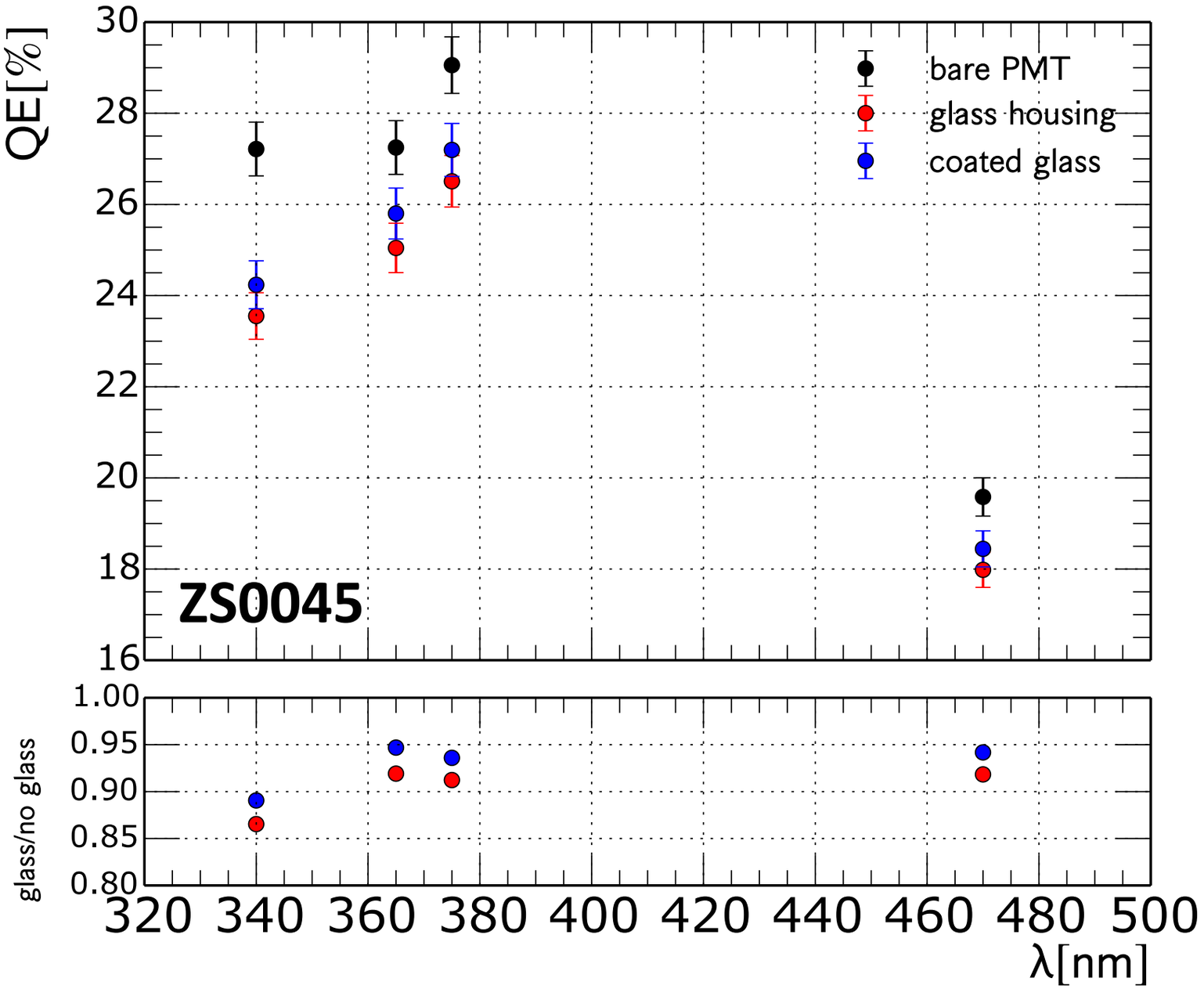
First measure the gain and charge response then QE

Use a set of 5 LED as source

Test with/without glass

First tests and measurements (results)

All credits Hans Niederhausen (Stony Brooks Uni.)



Current IC DOM:
max QE at 400nm: 22%
QE at 350nm: 7%

PMT QE improvement confirmed at low λ
~6% reduction for coated glass

Future test and time scale

Next months

- keep adding elements to the setup: PMT + glass + gel
- Freezing temperature test
- Still in spherical housing

Next year

- Jan./Feb: elliptical glass
- Test in larger freezer
- High pressure test (with high pressure water facility)

+ DOM simulation development (GEANT 4)

Summary

New DOM design: Double PMT optical module in elliptical glass housing

Design

- **2 HQ 8' PMT** back to back
- **Elliptical glass** with optimized thickness (simulated)

Material

- **Glass housing**: improvement around 300-400nm
- **Coating**: 2-4% improvement
- **Gel:** improvement all λ

Conclusion:

Overall gain especially at low λ

Confirmed by first test

High pressure test + freezing temp. foreseen next year