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Puerto Vallarta, México 8 -12 July

Tecnológico de Monterrey

Design, manufacturing and installation of multi-PMT vessel for Hyper-Kamiokande

11th July 2024 | Eng. Elisa Medina
on behalf of HK Mexico collaboration

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01.

Introduction

Hyper-Kamiokande (Hyper-K) is a water Cherenkov detector filled with 260,000 metric tons of ultrapure water.

What it will do?

- **Detect neutrinos** from accelerators, solar neutrinos and supernova neutrinos.
- Explore **CP violation** in neutrino oscillations.
- Determine neutrino **mass hierarchy**.
- Investigate **proton decay**.

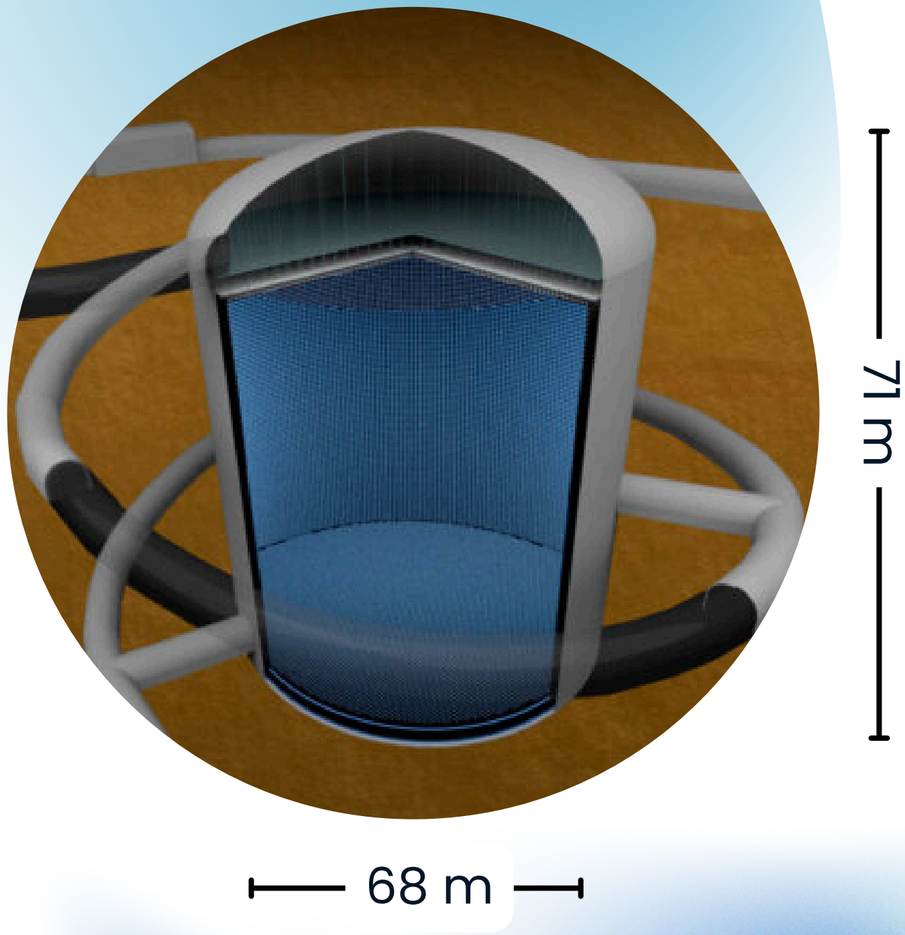
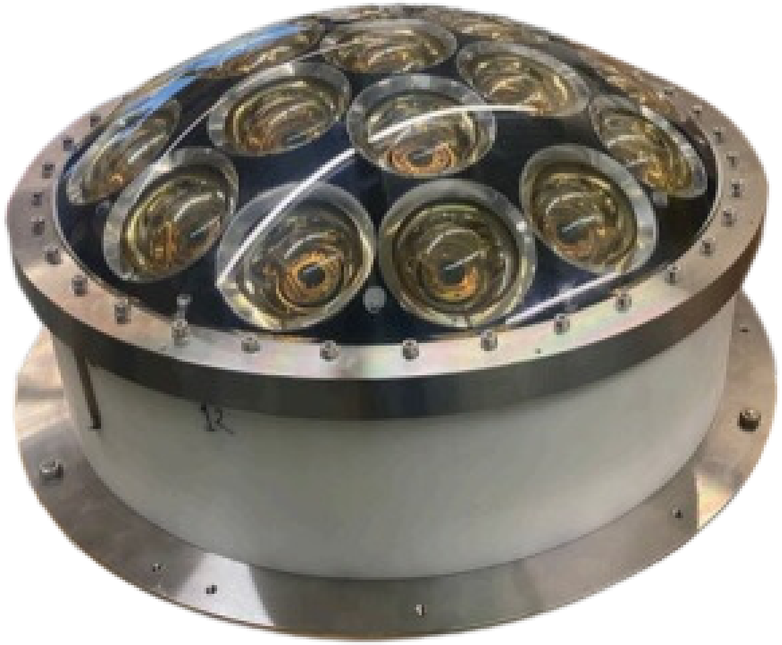


Image taken from Hyper-Kamiokande website

mPMT

The Hyper-K will be conformed by 800 **multi-PMT (mPMT)** optical modules.



20 inch

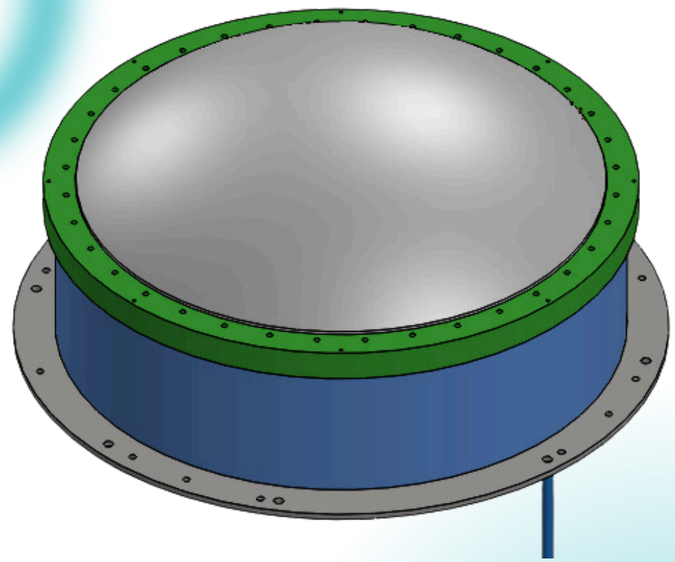
Image taken from Hyper-Kamiokande collaboration

Each mPMT has 19 **photomultiplier tubes (PMTs)**

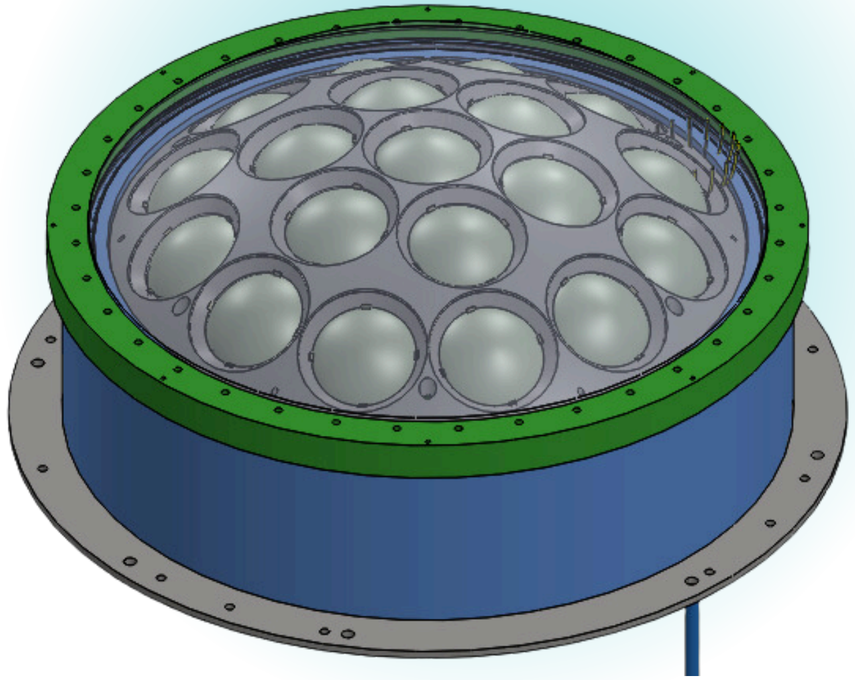
3 inch

02.

Mechanical Design



3D SolidWorks modeling of the mPMT vessel.



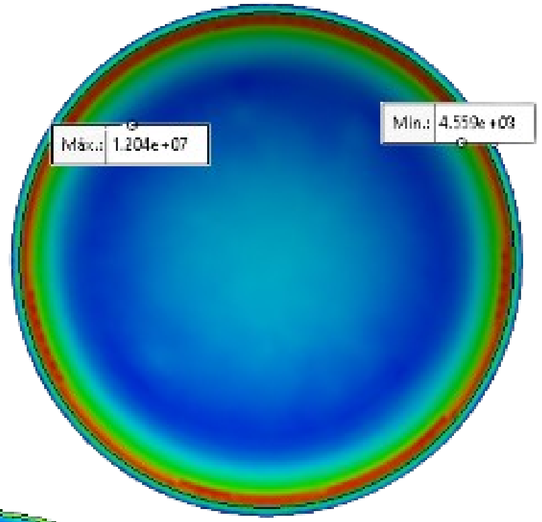
Computational simulations in **SolidWorks** for **stress analysis** due to the hydrostatic pressure suffered by the sensor vessel.

- Design improvement identification
- Simulation with new materials for the mPMT vessel.

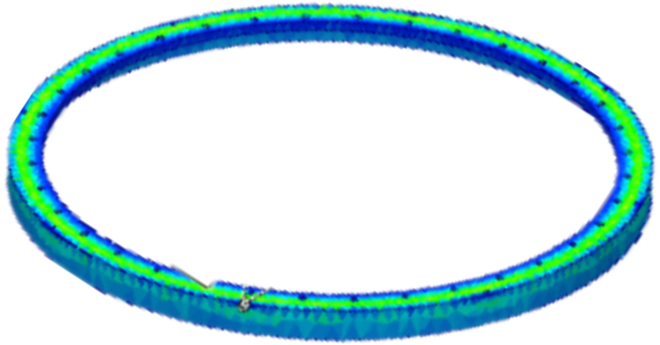
Stress simulations

0.7MPa

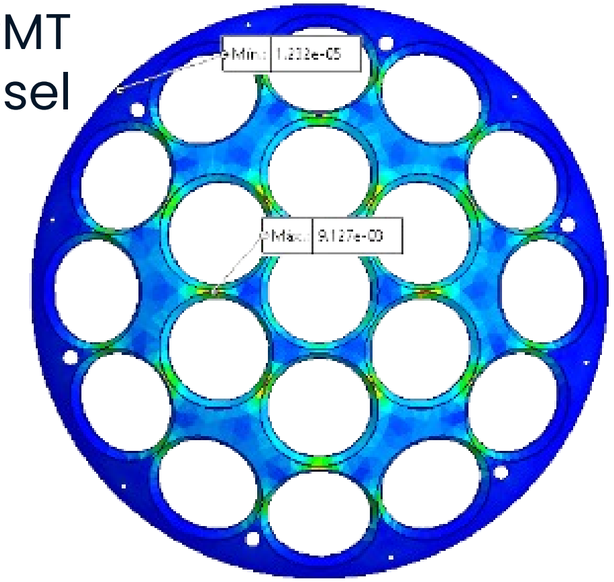
Acrylic Dome

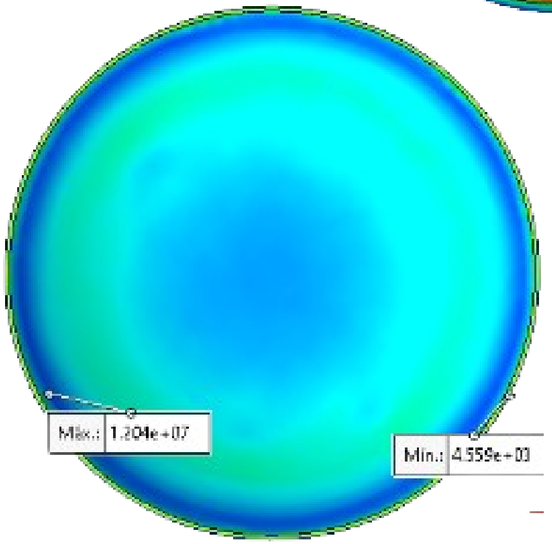


Clamping Ring

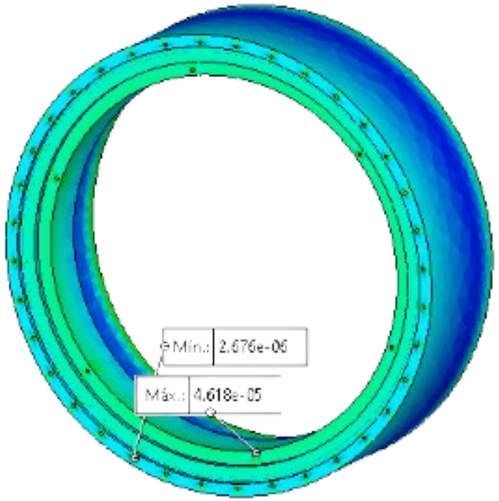


PMT vessel

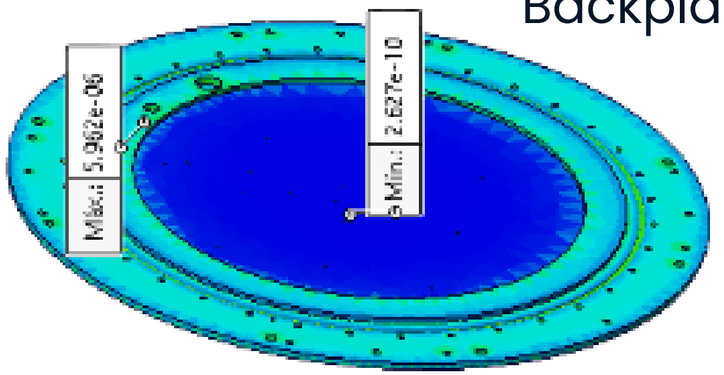




Cylinder



Backplate



Materials

02.

BUCKLING TEST

Pieza	Material	Factor de Carga
Domo	General Purpose Acrylic Resin	6.4392
	Röhm ACRYLITE	6.4132
Soporte de PMT	Acrilonitrilo butadieno estireno (ABS)	0.92119
	ABS (ABS834G40L)	2.4419
	PET-G	4.5832
Cilindro	POM-C	283.77
	HDPE	65.549
	AISI-304	13,042
Backplate	AISI-304	19,382
	Acero inoxidable AISI-316	19,741
Clamping Ring	AISI-304	2,863
	Acero inoxidable AISI-316	2,872

STRESS TEST

Pieza	Material	Límite elástico [N/m^2]	Limite max. simulación [N/m^2]	% de elasticidad máximo aplicado
Domo	General Purpose Acrylic Resin	3.907×10^{7}	1.204×10^{7}	30.81%
	Röhm ACRYLITE	5.199×10^{7}	1.204×10^{7}	23.16%
Soporte de PMT	Acrilonitrilo butadieno estireno (ABS)	2.000×10^{7}	1.289×10^{8}	644.50%
	ABS (ABS834G40L)	6.502×10^{7}	1.291×10^{8}	198.55%
	PET-G	1.007×10^{8}	1.154×10^{8}	114.60%
Cilindro	POM-C	5.102×10^{7}	1.270×10^{7}	24.89%
	HDPE	2.344×10^{7}	1.224×10^{7}	52.22%
	AISI-304	2.151×10^{8}	1.323×10^{7}	6.15%
Backplate	AISI-304	2.151×10^{8}	2.304×10^{6}	1.07%
	Acero inoxidable AISI-316	2.399×10^{8}	2.288×10^{6}	0.95%
Clamping Ring	AISI-304	2.151×10^{8}	1.106×10^{7}	5.14%
	Acero inoxidable AISI-316	2.399×10^{8}	1.110×10^{7}	4.63%

DEFORMATION TEST

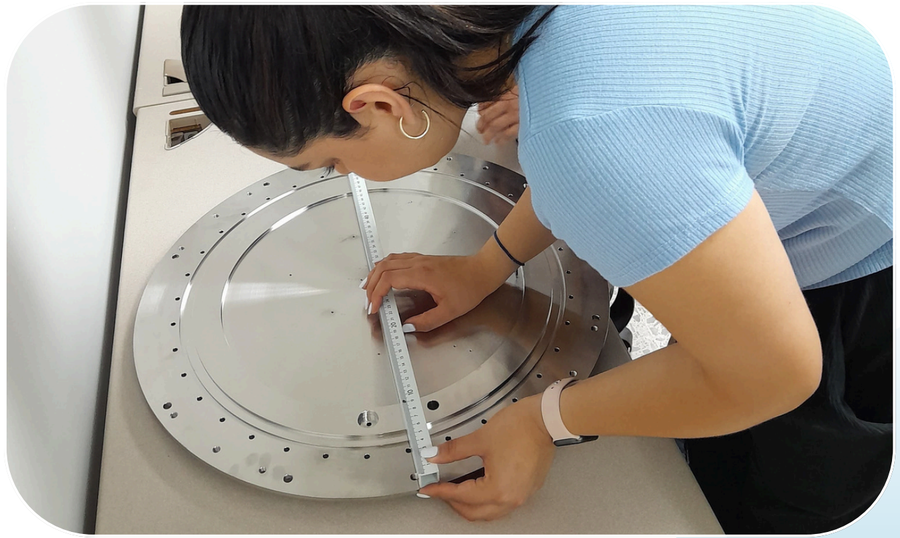
Pieza	Material	ESTRN Valor máximo [%]
Domo	General Purpose Acrylic Resin	3.461×10^{-1}
	Röhm ACRYLITE	3.475×10^{-1}
Soporte de PMT	Acrilonitrilo butadieno estireno (ABS)	5.128
	ABS (ABS834G40L)	1.924
	PET-G	9.127×10^{-1}
Cilindro	POM-C	2.264×10^{-1}
	HDPE	1.065×10^{-0}
	AISI-304	4.618×10^{-3}
Backplate	AISI-304	6.010×10^{-4}
	Acero inoxidable AISI-316	5.962×10^{-4}
Clamping Ring	AISI-304	5.152×10^{-3}
	Acero inoxidable AISI-316	5.158×10^{-3}

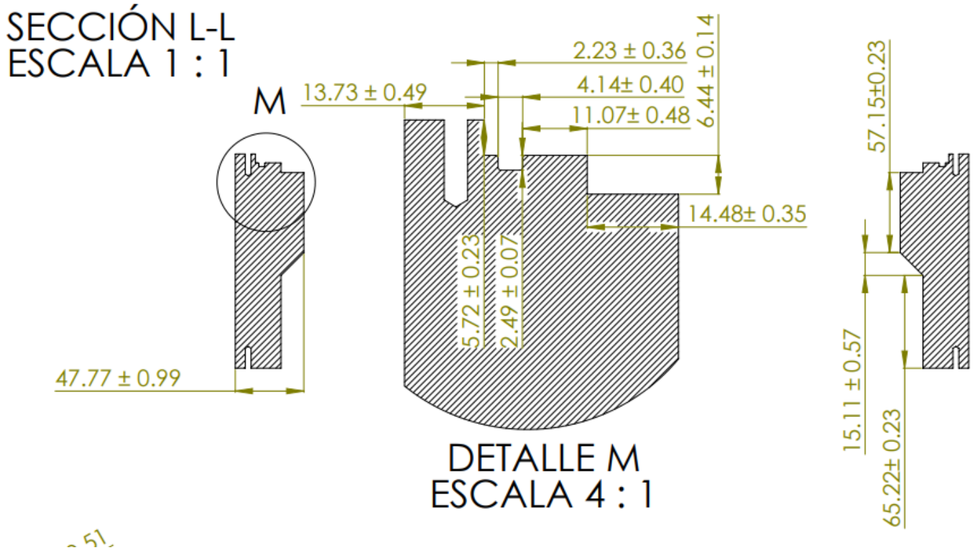
03.

Metrology

Measuring tools:

- Digital and analog vernier
- Rulers
- Flexometers





The **average** of all the **measurements** taken was obtained.

The dimensions were **confirmed** to be close to those of the SW model for the **fabrication of the PMT vessel**.

04.

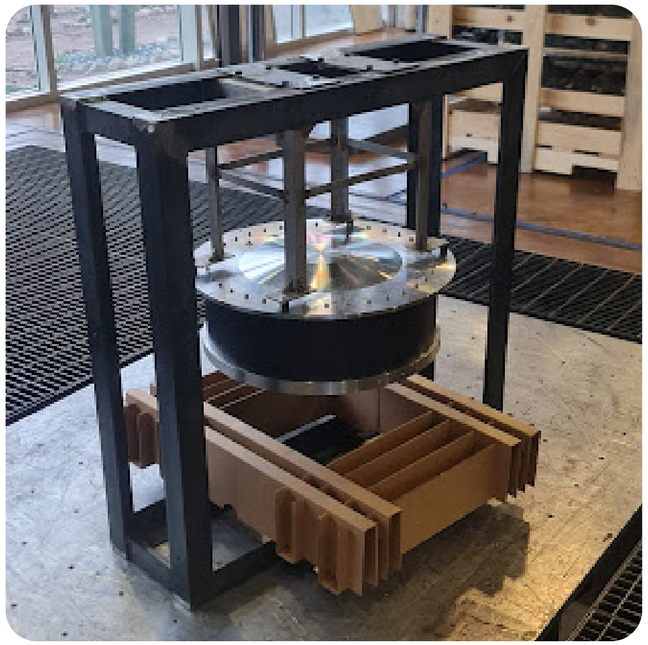
Testing

LOCATION

Tecnológico de Monterrey Campus Aguascalientes, México.

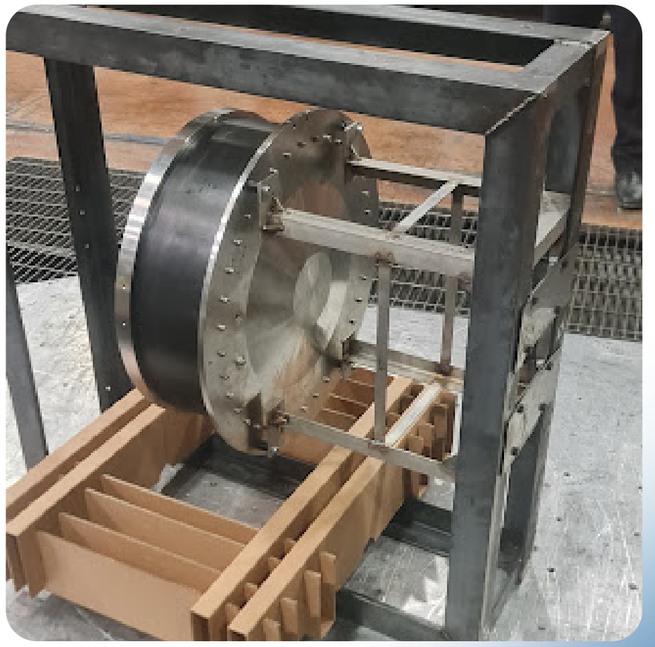
SUPPORT TESTING

Top



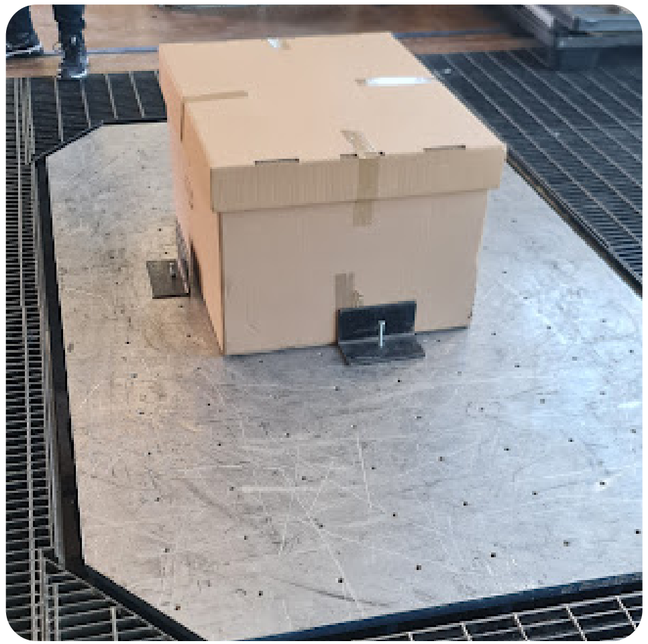
Bottom

Barrel



SHIPPING PACKAGING TESTING

Vibrating table



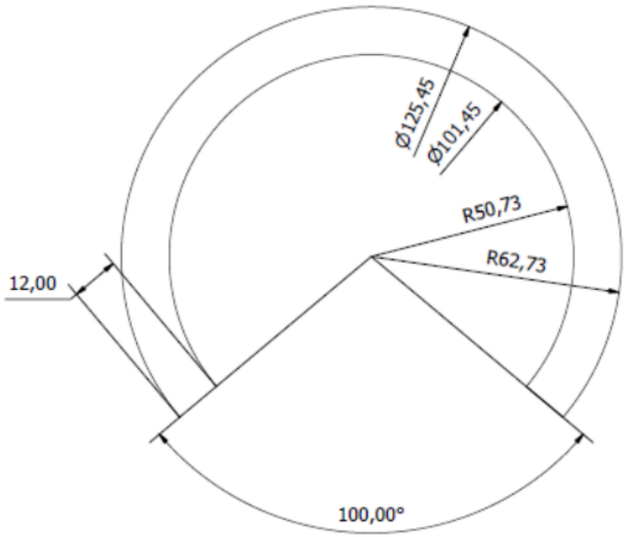
Compression piston

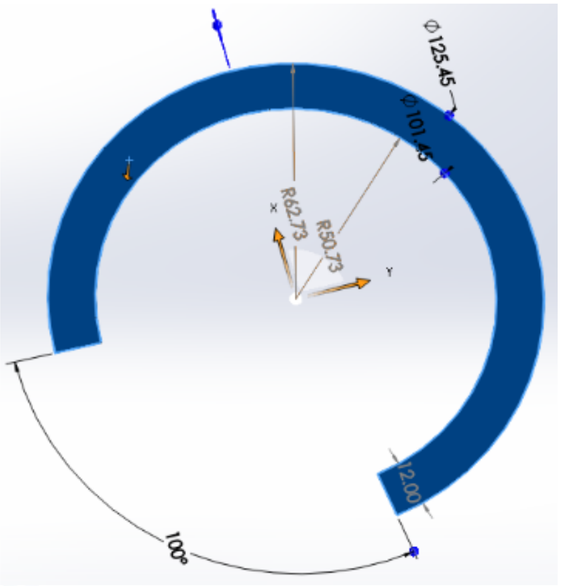
Humidity chamber

05.

Reflector rings

2D design from "mPMT Technical Note v5" (2023)





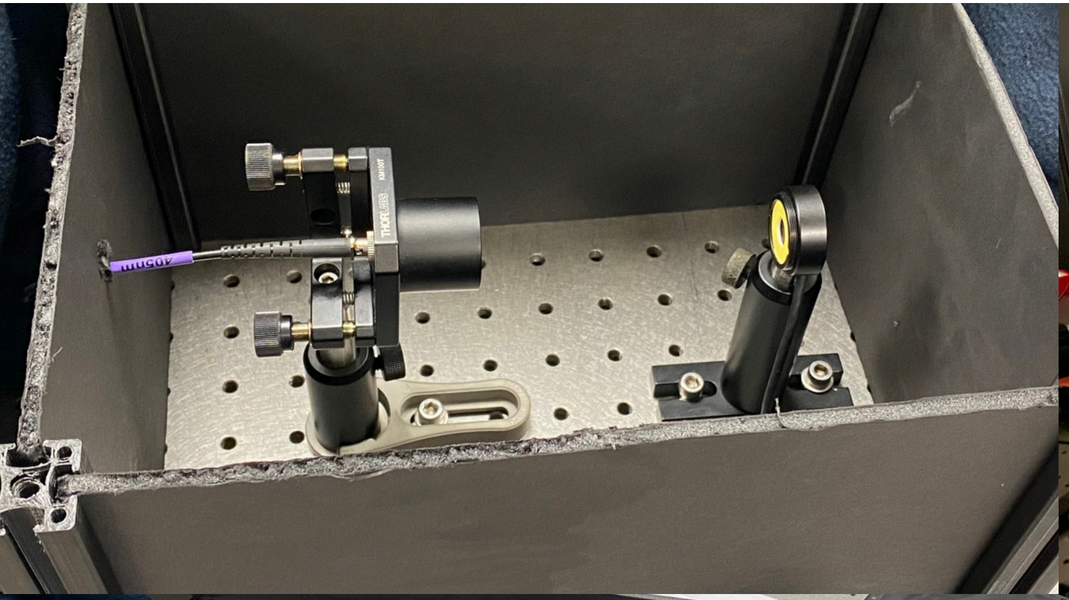
Cutting

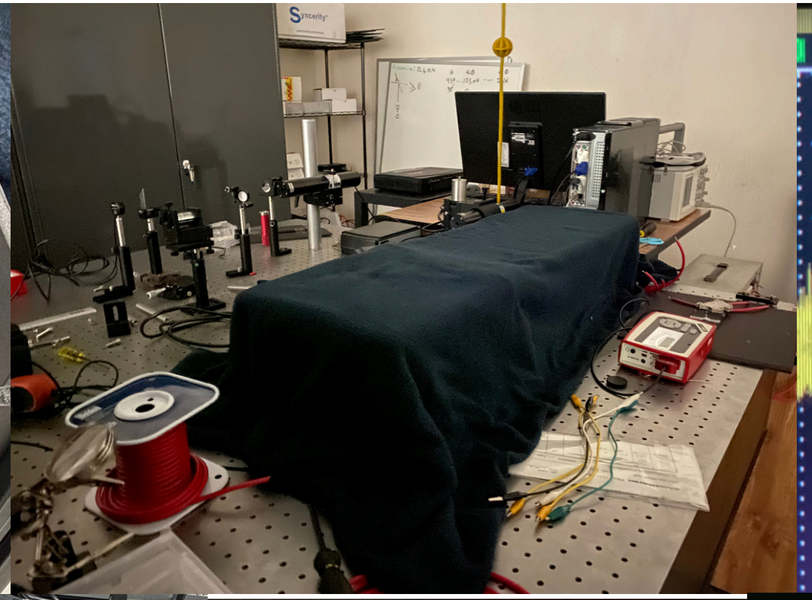
- 26-gauge aluminum sheet, 0.46mm thickness
- Plasma cutter

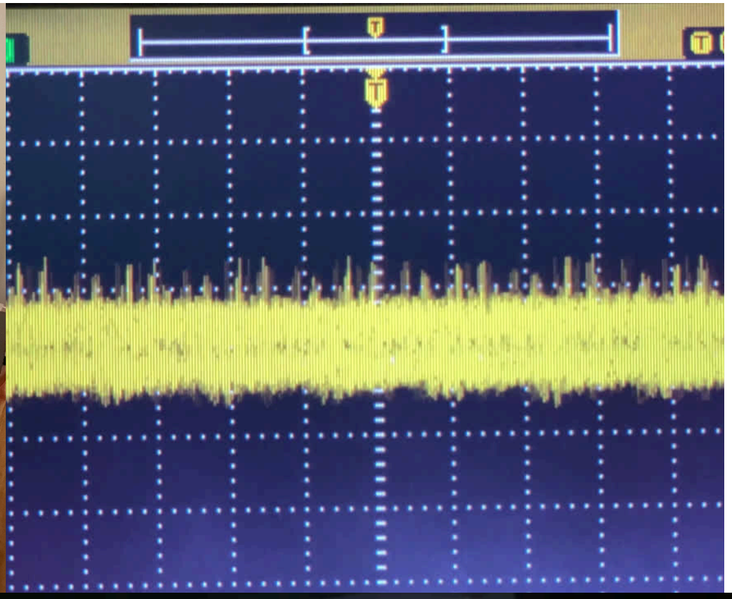
06.

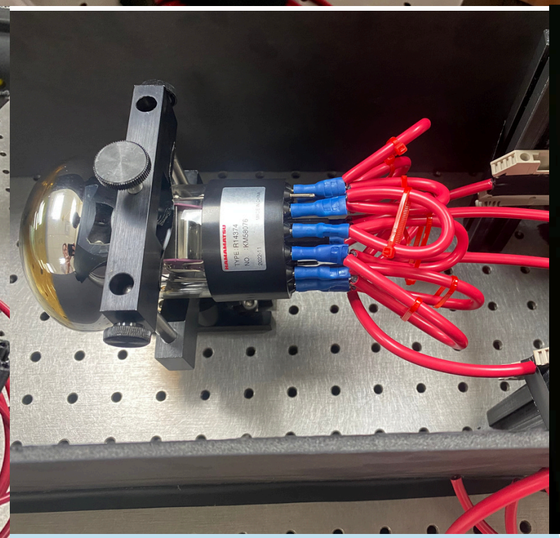
Characterization of a PMT

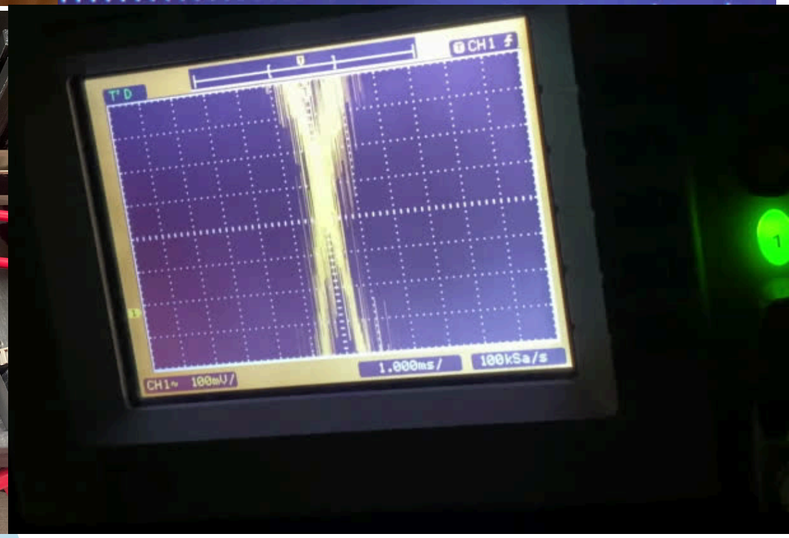
By Eng. Rodrigo Medina











07.

Conclusions

The work done by the **Mexican students and researchers** contributed to the development of the project and set the stage for **more in-depth analyses** on various topics, which could lead to **improvement proposals**.

Thank you!

Know more in Outreach HK México

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