OUTREACH HYPER-KAMIOKANDE MEXICO

STUDENT SCIENTIFIC OUTREACH GROUP IN MEXICO

SPEAKERS

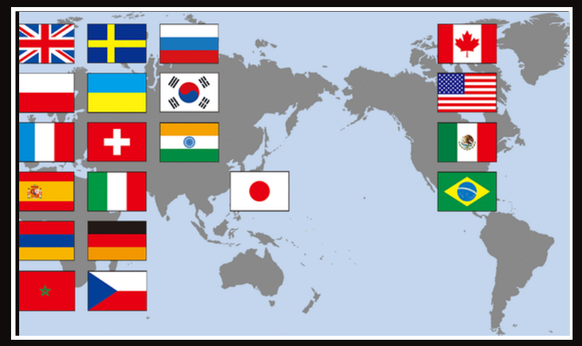
Eng. Judith Torres Jiménez &
Montserrat Montiel Dücker Romero

ISVHECRI 2024

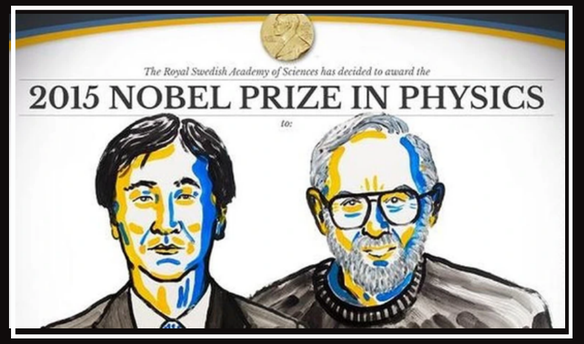
Puerto Vallarta, Jalisco.

OUTREACH HYPER-KAMIOKANDE

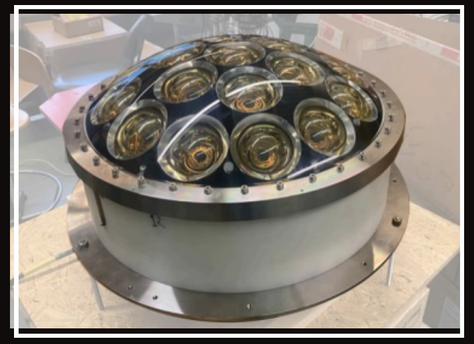
(a) Hyper-Kamiokande



(b) Internacional Colaboration HK



(c) 2015 Nobel Laureate



(d) mPMT Assembly

Type: Neutrino observatory
Location: Near Kamioka, Japan
Size: 10 times larger than its predecessor, Super-Kamiokande
Purpose: Study of neutrino properties, proton decay, and cosmic phenomena

Technology: Utilizes a vast tank of ultra-pure water with advanced photodetectors called PMT's
Significance: Expected to provide critical insights into fundamental physics and the universe's evolution

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OUR MISSION

- Share information regarding the contribution of Mexico in the Hyper-Kamiokande project.

- Highlight the importance of this partnership as one of the most ambitious scientific research collaborations for our nation.

Photo obtained from Hyper-Kamiokande gallery.

ORIGINS OF THE OUTREACH HK MEXICO COLLABORATION

PHD. EDUARDO DE LA FUENTE
PHD. SAUL CUEN-ROCHIN
2020
THE MEXICAN COLLABORATION WAS FORMALIZED.
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PROTO-COLLABORATION

FIG. 2 10TH HYPER-KAMIOKANDE PROTO-COLLABORATION MEETING, AT THE UNIVERSITY OF TOKYO CAMPUS IN KASHIWA, JAPAN ON FEBRUARY 5–9, 2020. CREDIT HYPER-K PROTO-COLLABORATION

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RESEARCH PROFESSORS

Prof. Akira Konaka

PhD. Saul Cuen-Rochin

Prof. Takaaki Kajita
(Nobel Laureate)

PhD. Eduardo de la Fuente

PhD. Kadsumi Tomatani

RESEARCH PROFESSORS

PhD. Rajesh Roshan Biswal

PhD. Christoper Edgar Falcón Anaya

PhD. Luis Eduardo Falcón Morales

PhD. Rodrigo Gamboa Goñi

PhD. José Rodrigo Salmón-Folgueras

PhD. Karen Salomé Caballero Mora

PhD. Giannina Della Mese Zavala

INITIATED BY PHD. KADSUMI TOMATANI

- Disseminate the progress and accomplishments
- Emphasize the importance of the partnership between Mexican universities

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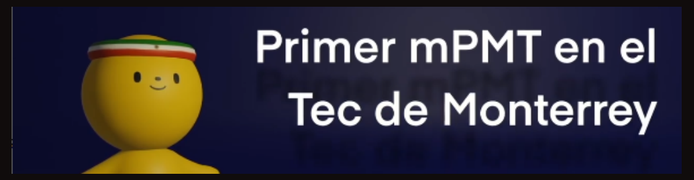

La profesora Francesca Di Lodovico es la actual portavoz internacional del proyecto Hyper-Kamiokande. Este es su segundo período en este cargo, ya que fue elegida previamente en 2020 y nuevamente en 2023.

HTTPS://HYPERKAMIOKANDE.TEC.MX/ES

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FORMER STUDENTS

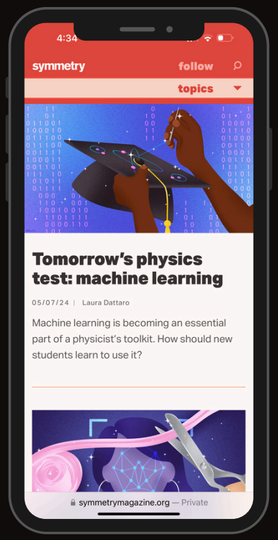
Gilberto Rodriguez Prado

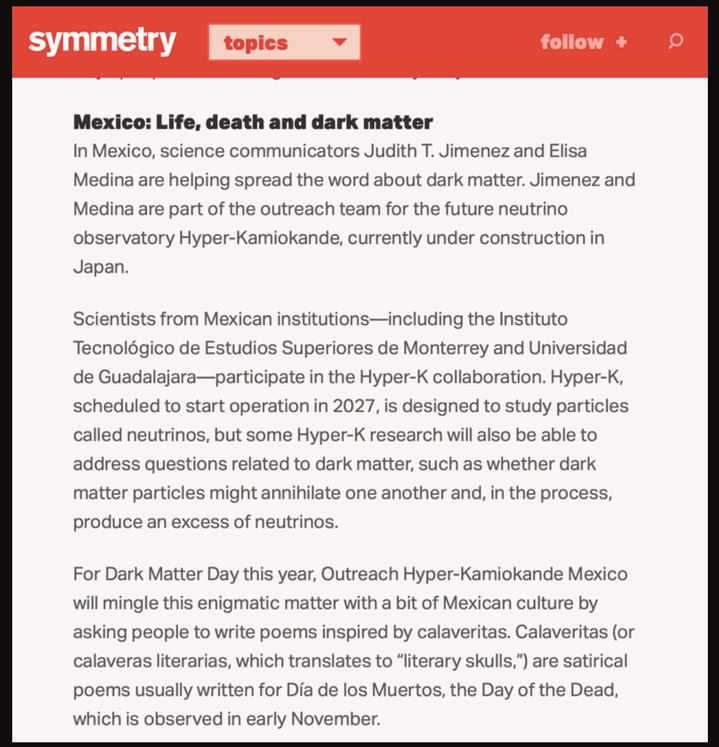
Lazaro Maximiliano Salas Valtierra

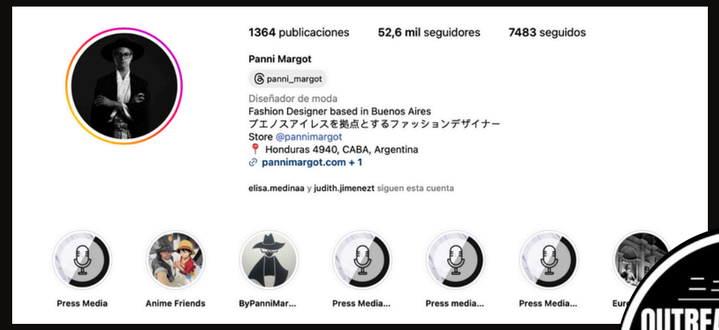
Elías Abisaí Avedaño Lara

Elrick Haces Gil

STUDENT GROUPS COLLABORATION







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ADVANCES AND AWARDS

HYPER-KAMIOKANDE MEXICO COLLABORATION

1 TWO FRONTIER SCIENCE AWARDS

UNIVERSIDAD DE GUADALAJARA

PIENSA Y TRABAJA

2023 $112,071.88 USD

2024 $65,091.67 USD

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1 NOVUS PROJECT

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Tecnológico de Monterrey

$263,015.55 MXN AWARD

$30,829.41 MXN FOR PMT

2

DATA ANALYSIS: CLASSIFYING TYPES OF NEUTRINOS IN PREPARATION FOR 2027 DATA

MASTER MARÍA FERNANDA

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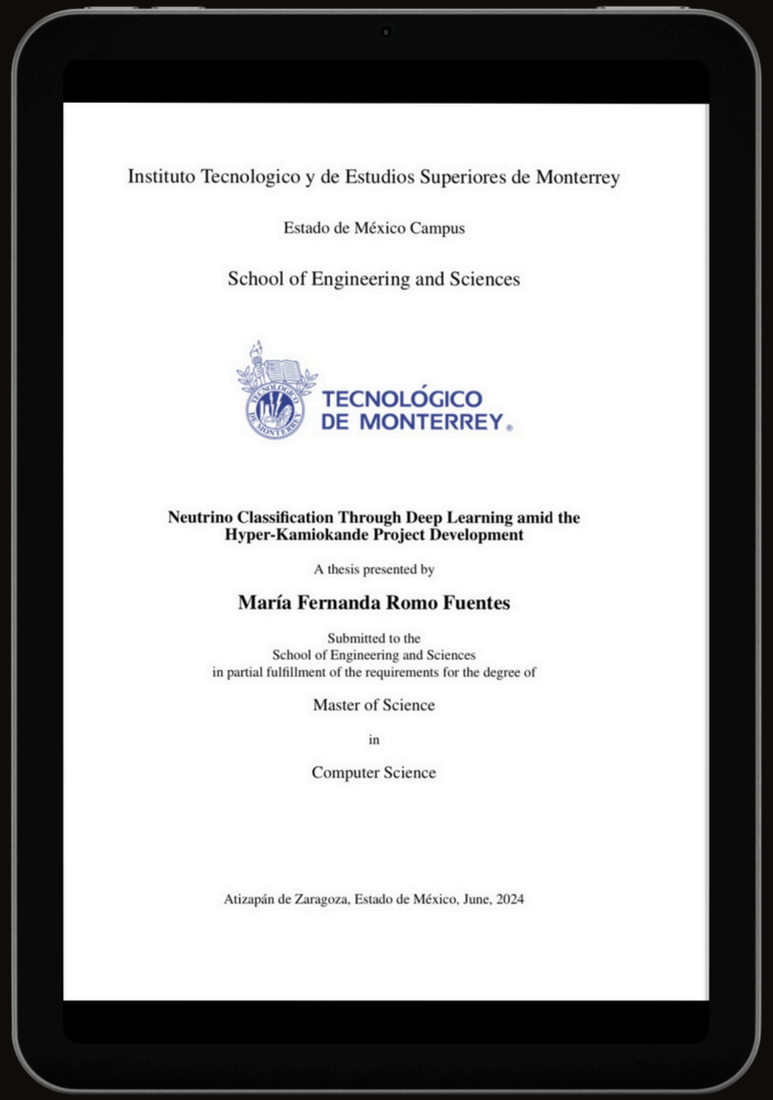
2 A THESIS PRESENTED BY MASTER MARIA FERNANDA



Instituto Tecnologico y de Estudios Superiores de Monterrey

Estado de México Campus

School of Engineering and Sciences

TECNOLÓGICO DE MONTERREY®

Neutrino Classification Through Deep Learning amid the Hyper-Kamiokande Project Development

A thesis presented by

María Fernanda Romo Fuentes

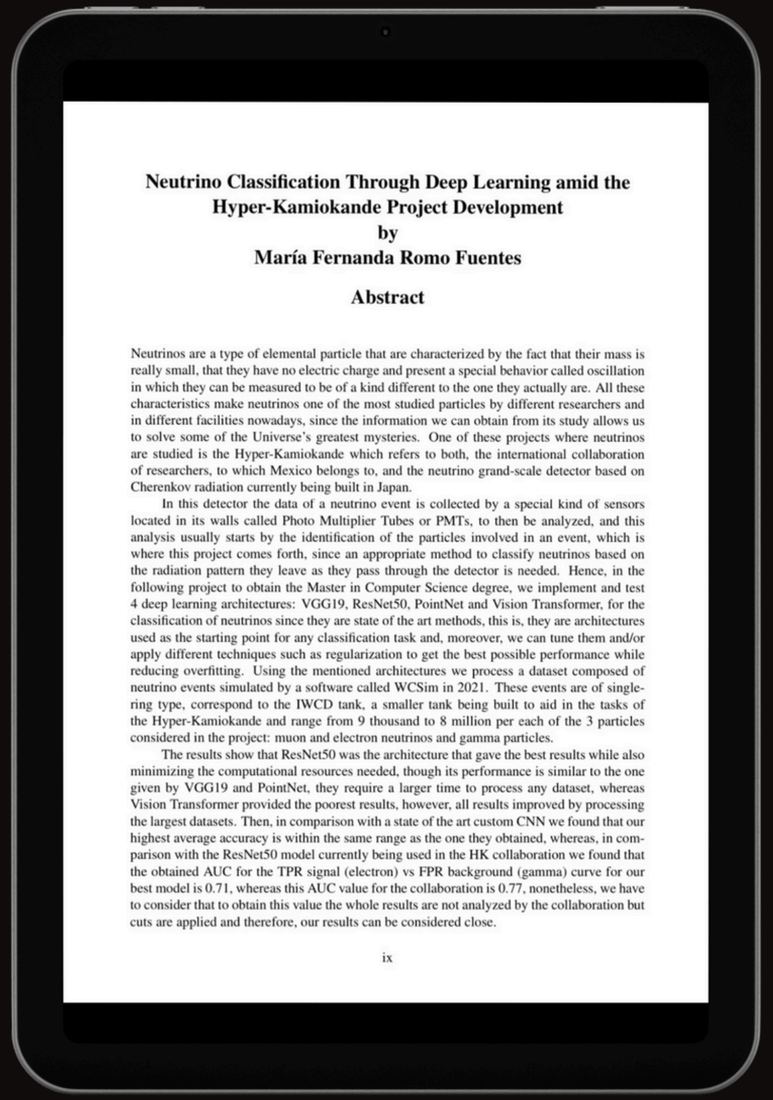
Submitted to the
School of Engineering and Sciences
in partial fulfillment of the requirements for the degree of

Master of Science

in

Computer Science

Atizapán de Zaragoza, Estado de México, June, 2024



Neutrino Classification Through Deep Learning amid the Hyper-Kamiokande Project Development
by
María Fernanda Romo Fuentes

Abstract

Neutrinos are a type of elemental particle that are characterized by the fact that their mass is really small, that they have no electric charge and present a special behavior called oscillation in which they can be measured to be of a kind different to the one they actually are. All these characteristics make neutrinos one of the most studied particles by different researchers and in different facilities nowadays, since the information we can obtain from its study allows us to solve some of the Universe's greatest mysteries. One of these projects where neutrinos are studied is the Hyper-Kamiokande which refers to both, the international collaboration of researchers, to which Mexico belongs to, and the neutrino grand-scale detector based on Cherenkov radiation currently being built in Japan.

In this detector the data of a neutrino event is collected by a special kind of sensors located in its walls called Photo Multiplier Tubes or PMTs, to then be analyzed, and this analysis usually starts by the identification of the particles involved in an event, which is where this project comes forth, since an appropriate method to classify neutrinos based on the radiation pattern they leave as they pass through the detector is needed. Hence, in the following project to obtain the Master in Computer Science degree, we implement and test 4 deep learning architectures: VGG19, ResNet50, PointNet and Vision Transformer, for the classification of neutrinos since they are state of the art methods, this is, they are architectures used as the starting point for any classification task and, moreover, we can tune them and/or apply different techniques such as regularization to get the best possible performance while reducing overfitting. Using the mentioned architectures we process a dataset composed of neutrino events simulated by a software called WCSim in 2021. These events are of single-ring type, correspond to the IWCD tank, a smaller tank being built to aid in the tasks of the Hyper-Kamiokande and range from 9 thousand to 8 million per each of the 3 particles considered in the project: muon and electron neutrinos and gamma particles.

The results show that ResNet50 was the architecture that gave the best results while also minimizing the computational resources needed, though its performance is similar to the one given by VGG19 and PointNet, they require a larger time to process any dataset, whereas Vision Transformer provided the poorest results, however, all results improved by processing the largest datasets. Then, in comparison with a state of the art custom CNN we found that our highest average accuracy is within the same range as the one they obtained, whereas, in comparison with the ResNet50 model currently being used in the HK collaboration we found that the obtained AUC for the TPR signal (electron) vs FPR background (gamma) curve for our best model is 0.71, whereas this AUC value for the collaboration is 0.77, nonetheless, we have to consider that to obtain this value the whole results are not analyzed by the collaboration but cuts are applied and therefore, our results can be considered close.

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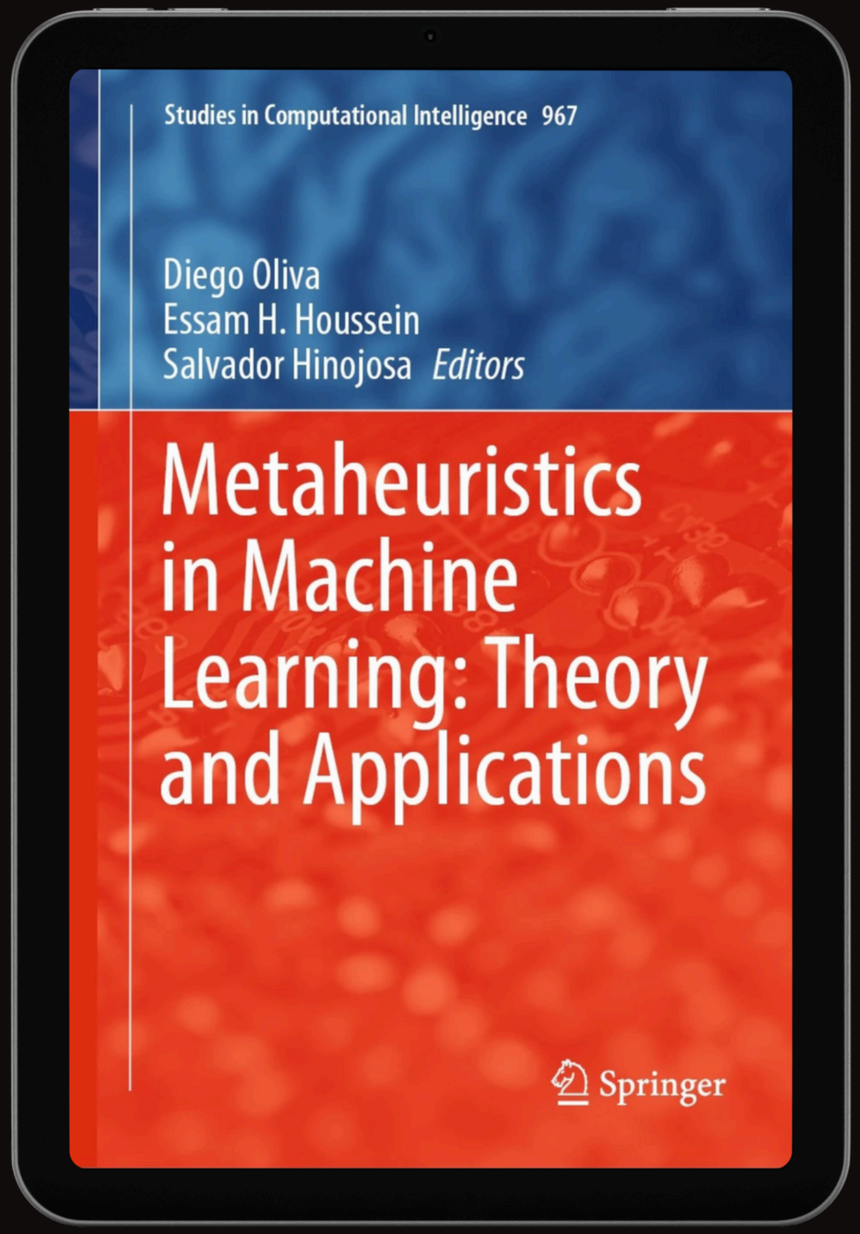

HYPER-KAMIOKANDE PARTICIPATION IN CHAPTER 23

3

Machine Learning Application for Particle Physics: Mexico's Involvement in the Hyper-Kamiokande Observatory

Check for updates

S. Cuen-Rochin, E. de la Fuente, L. Falcon-Morales, R. Gamboa Goni, A. K. Tomatani-Sanchez, F. Orozco-Luna, H. Torres, J. Lozoya, J. A. Baeza, J. L. Flores, B. Navarro-Garcia, B. Veliz, A. Lopez, and B. Gonzalez-Alvarez

SUPERCOMPUTING FACILITIES IN MEXICO TO BE USED ON HYPER-K:

- *Supercomputing at ITESM, Campus Guadalajara, Jalisco, Mexico*
- *The Centro de Análisis de Datos y Supercómputo (CADS)-Universidad de Guadalajara, Jalisco, Mexico*

MACHINE LEARNING THEORY
CNN APPLICATION FOR PARTICLE IDENTIFICATION IN THE HYPER-KAMIOKANDE EXPERIMENT

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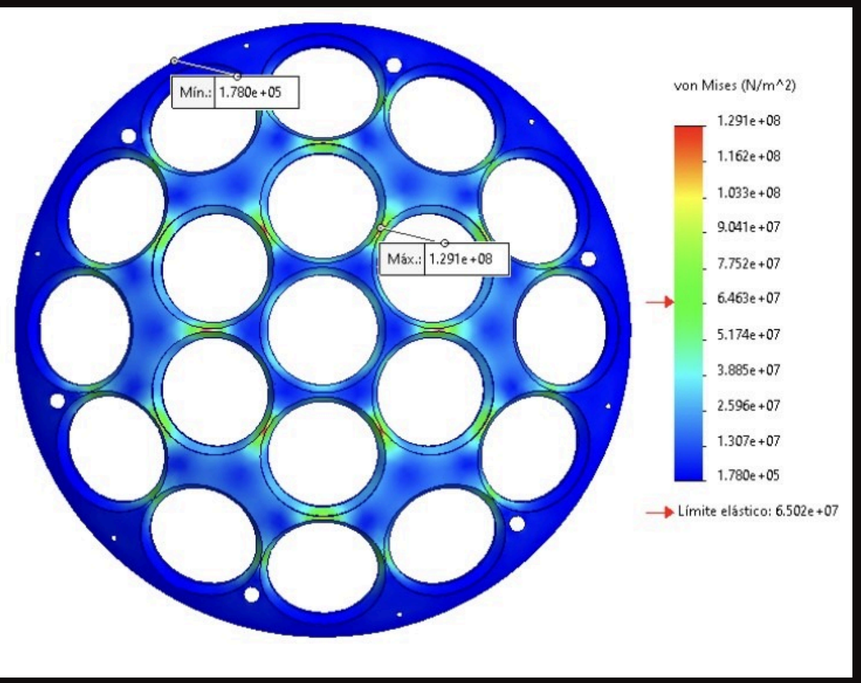
4



ENG. ELISA MEDINA

MECHANICAL STRUCTURE ANALYSIS OF THE MULTI-PMT SENSOR IN SOLID WORKS

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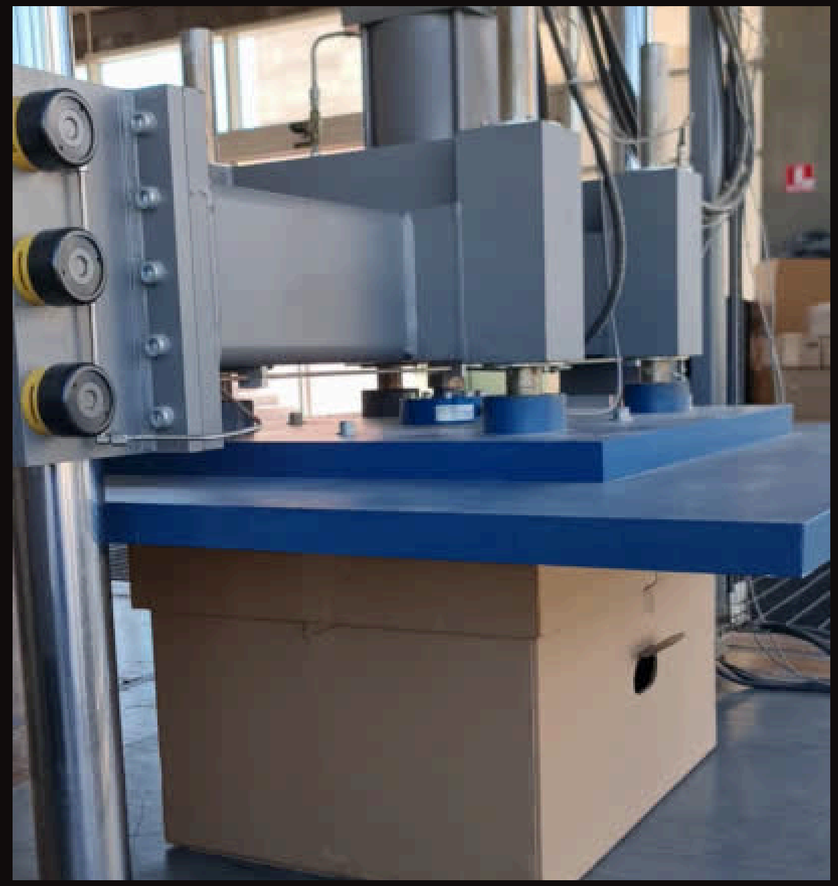
4 MECHANICAL STRUCTURE ANALYSIS OF THE MULTI-PMT SENSOR



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MECHANICAL STRUCTURE ANALYSIS OF THE MULTI-PMT SENSOR

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MECHANICAL STRUCTURE ANALYSIS OF THE MULTI-PMT SENSOR IN SOLID WORKS

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5 UNIVERSITIES IN THE COLLABORATION

UNIVERSIDAD DE GUADALAJARA
PIENSA Y TRABAJA

UNIVERSIDAD AUTONOMA DE SINALOA
SURSUM VERSUS

Tecnológico de Monterrey

UNACH
UNIVERSIDAD AUTONOMA DE CHIAPAS
POR LA CONCIENCIA DE LA NECESIDAD DE SERVIR

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6 MOU WITH THE UNIVERSITY OF TOKYO

東京大学
THE UNIVERSITY OF TOKYO

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Photo obtained from Hyper-Kamiokande gallery.

THANK YOU ISVHECRI!

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MEXICO

References:

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