



Tecnológico
de Monterrey



OUTREACH HYPER-KAMIOKANDE MEXICO

STUDENT SCIENTIFIC OUTREACH GROUP
IN MEXICO

SPEAKERS

Eng. Judith Torres Jiménez &
Montserrat Montiel Dücker Romero

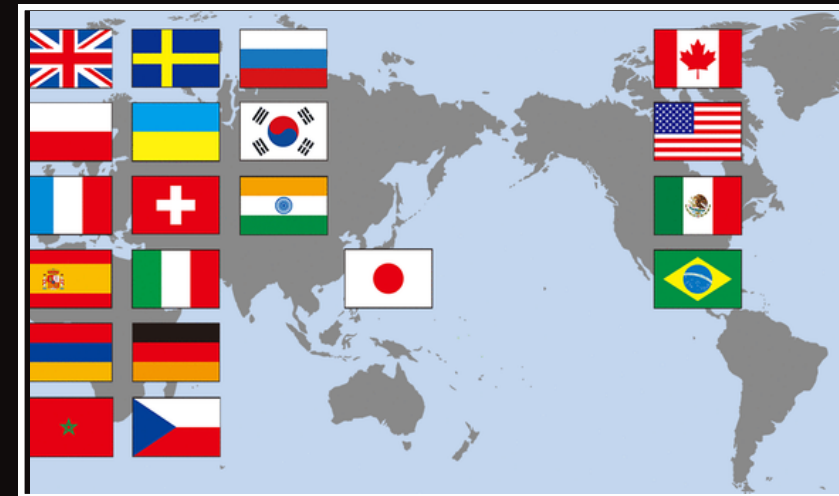
ISVHECRI 2024

Puerto Vallarta, Jalisco.

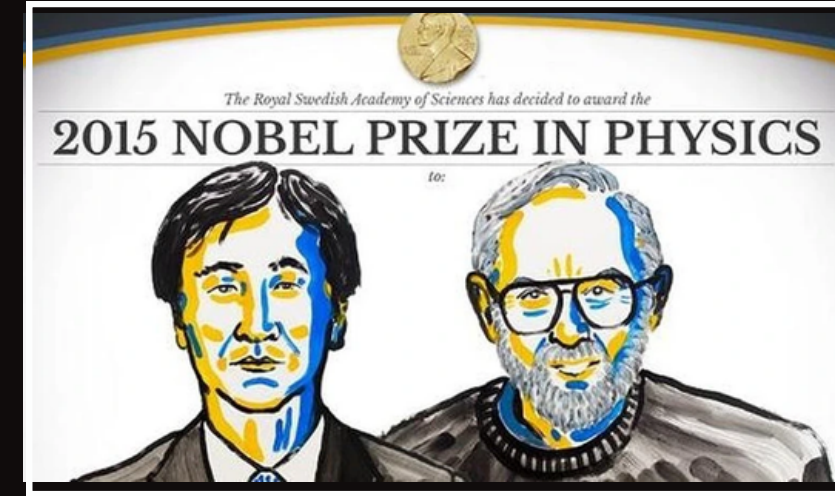
OUTREACH HYPER-KAMIOKANDE



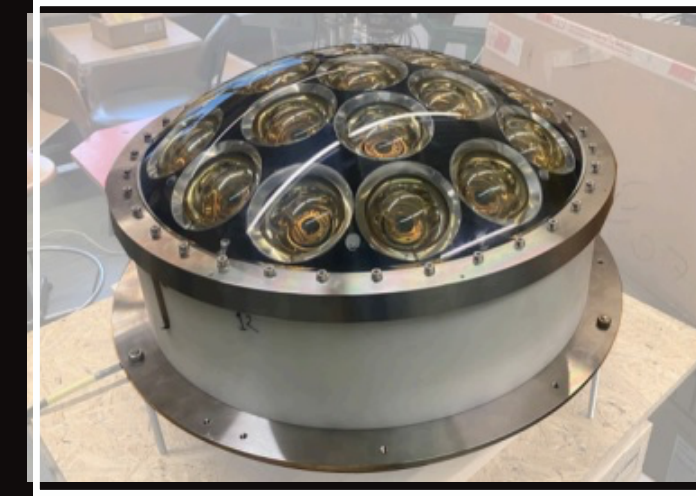
(a) Hyper-Kamiokande



(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



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

Rodríguez

Gerardo Pineda

Blazer

Herzon Souza

AP-TEC

Roy Esparza

Edgar Hernández

Hugo Álvarez

Elisa Medina

Yolanda Ramírez

Crino Miranda

Daniel Erro

Blazer

PHD. EDUARDO DE LA FUENTE

PHD. SAUL CUEN-ROCHIN

2020

THE **MEXICAN** COLLABORATION WAS FORMALIZED.



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



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





Ensamble de un sensor de radiación Cherenkov de Hyper-Kamiokande



Bloque de 8vo semestre: F3001B Integración de Ingeniería Física

Consta de 10 semanas continuas (semana 7 a la 16).
Impartido por **Dr. Rodrigo Salmón** y socios formadores integrantes de la colaboración internacional de **Hyper-Kamiokande**.



Este reto está relacionado con el **diseño, construcción y ensamblado** del soporte de un sensor mPMT (multi tubo fotomultiplicador).

Para más información sobre Hyper-Kamiokande visita:



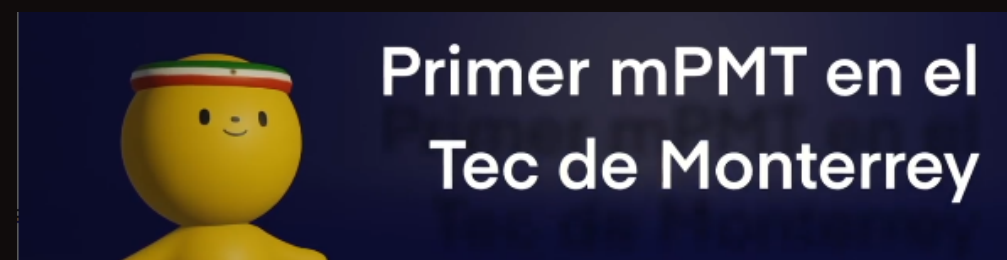
Medición de los **neutrinos atmosféricos**



Hyper-k: detector de neutrinos atmosféricos, solares y de supernova

Saul Cuen Rochin

Agosto 26, 2021
Tec de Monterrey



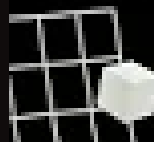
Primer mPMT en el Tec de Monterrey



Modelos de Deep Learning para entender los neutrinos que nos llegan del espacio profundo.



Dr. Luis Eduardo Falcón Morales



Celebrating Dark Matter Day in Latin America



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](https://hyperkamiokande.tec.mx/es)



OUTREACH.HKMEXICO@GMAIL.COM



**Tecnológico
de Monterrey**

FORMER STUDENTS



Gilberto Rodriguez Prado



Lazaro Maximiliano Salas Valtierra



Elías Abisaí Avedaño Lara

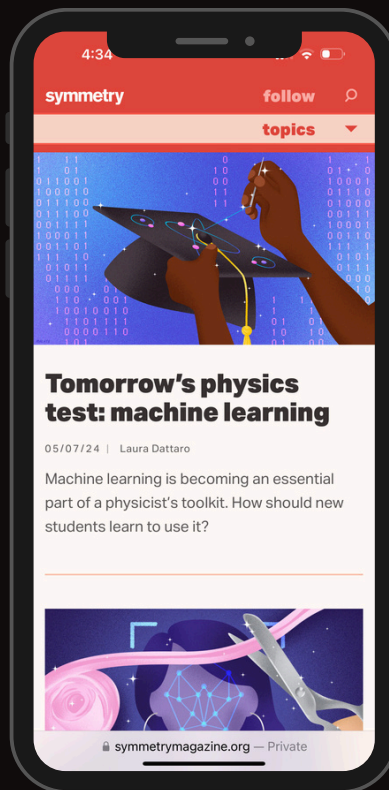


Elrick Haces Gil



STUDENT GROUPS COLLABORATION





ANDES General information For scientists News Outreach #darkmatterday2023

Día Internacional de la Materia Oscura

En Argentina, desde la coordinación del Laboratorio Subterráneo ANDES, en conjunto con el Laboratorio de Detección de Radiación y Partículas del Centro Atómico Bariloche y en México, desde el Laboratorio Subterráneo de Mineral del Chico (LABChico), el Outreach México Hyper-K y Adivulgando tenemos el agrado de invitarlos a las celebraciones por el "Día Internacional de la Materia Oscura" (31 de Oct 2021).

Este evento, de carácter internacional, convoca a distintas instituciones involucradas en el área de Astrofísica y la Física de Partículas para la realización de actividades comunes con la finalidad de visibilizar la investigación científica en la temática "Materia Oscura", así como también el aspecto humano de esta búsqueda de conocimiento.

En esta oportunidad, fueron invitadas niñas, niños y jóvenes de América Latina a crear una obra de arte basada en esas dos preguntas:
 ¿Cómo te imaginás una máquina para atrapar la materia oscura?
 ¿Quién podría operar esta misteriosa máquina?

Resultados (186 obras!)

Agradecemos mucho los hermosos dibujos que hemos recibido. Cada dibujo enlaza a un video con un científico o una científica comentándolo. Hagan click sobre los dibujos!

symmetry topics follow +

Mexico: Life, death and dark matter

In Mexico, science communicators Judith T. Jimenez and Elisa Medina are helping spread the word about dark matter. Jimenez and Medina are part of the outreach team for the future neutrino observatory Hyper-Kamiokande, currently under construction in Japan.

Scientists from Mexican institutions—including the Instituto Tecnológico de Estudios Superiores de Monterrey and Universidad de Guadalajara—participate in the Hyper-K collaboration. Hyper-K, scheduled to start operation in 2027, is designed to study particles called neutrinos, but some Hyper-K research will also be able to address questions related to dark matter, such as whether dark matter particles might annihilate one another and, in the process, produce an excess of neutrinos.

For Dark Matter Day this year, Outreach Hyper-Kamiokande Mexico will mingle this enigmatic matter with a bit of Mexican culture by asking people to write poems inspired by calaveritas. Calaveritas (or calaveras literarias, which translates to "literary skulls,") are satirical poems usually written for Día de los Muertos, the Day of the Dead, which is observed in early November.



1364 publicaciones 52,6 mil seguidores 7483 seguidos

Panni Margot
 @panni_margot
 Diseñador de moda
 Fashion Designer based in Buenos Aires
 ブエノスアイレスを拠点とするファッションデザイナー
 Store @pannimargot
 Honduras 4940, CABA, Argentina
 pannimargot.com + 1

elisa.medinaa y judith.jimenezt siguen esta cuenta



[HTTPS://HYPERKAMIOKANDE.TEC.MX/ES](https://hyperkamiokande.tec.mx/es)



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ADVANCES AND AWARDS

HYPER- **KAMIOKANDE** **MEXICO** **COLLABORATION**

1 TWO FRONTIER SCIENCE AWARDS



2023 \$112,071.88 USD

2024 \$65,091.67 USD



Tecnológico de Monterrey



1 NOVUS PROJECT



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



2

A THESIS PRESENTED BY MASTER MARIA FERNANDA

Instituto Tecnológico y de Estudios Superiores de Monterrey

Estado de México Campus

School of Engineering and Sciences



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

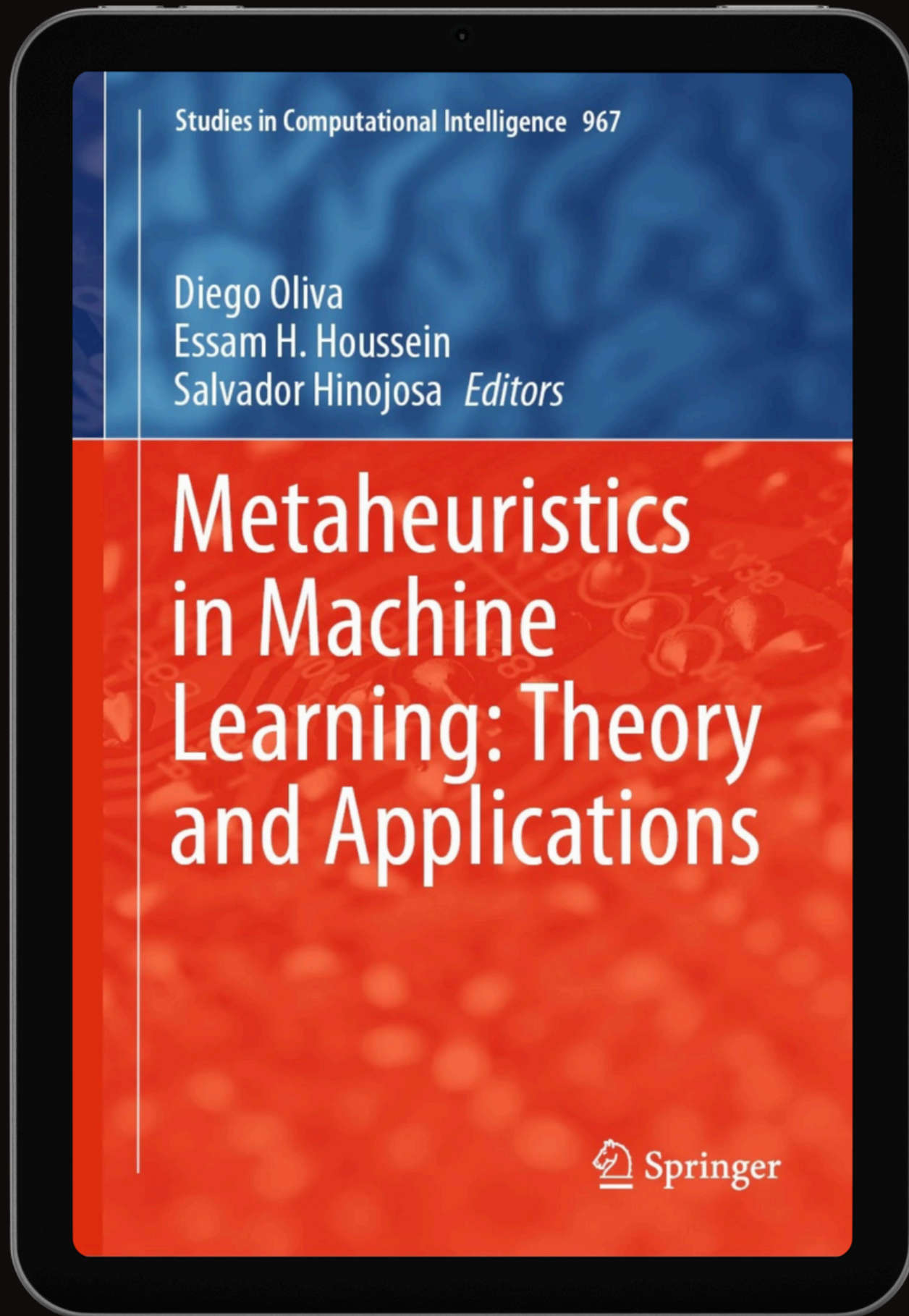
Neutrinos are a type of elemental particle that are characterized by the fact that their mass is really small, that they have no electric charge and present a special behavior called oscillation in which they can be measured to be of a kind different to the one they actually are. All these characteristics 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.

ix





HYPER-KAMIOKANDE PARTICIPATION IN CHAPTER 23

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



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

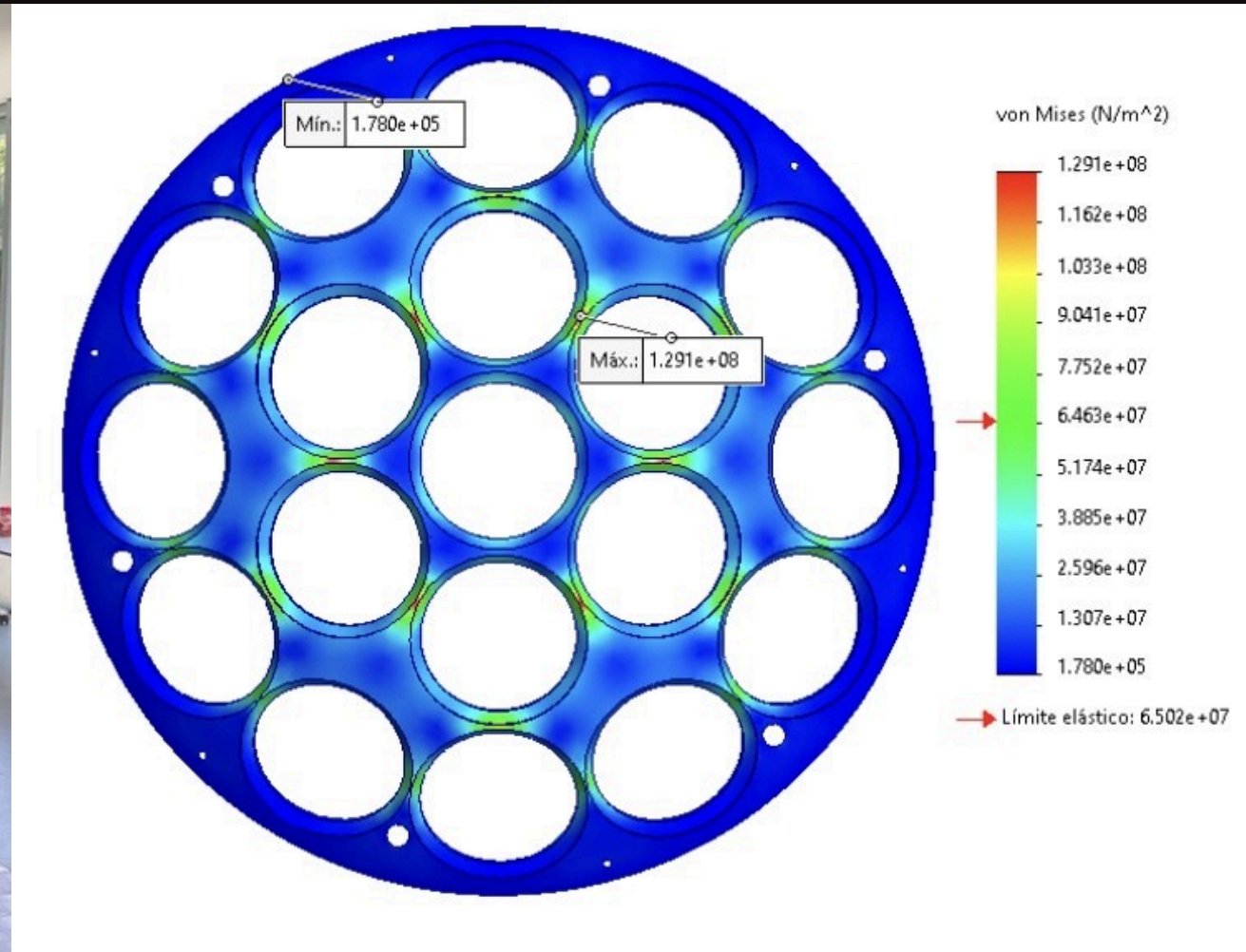
SUPERCOMPUTING FACILITIES IN MEXICO TO BE USED ON HYPER-K:

- *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*



4



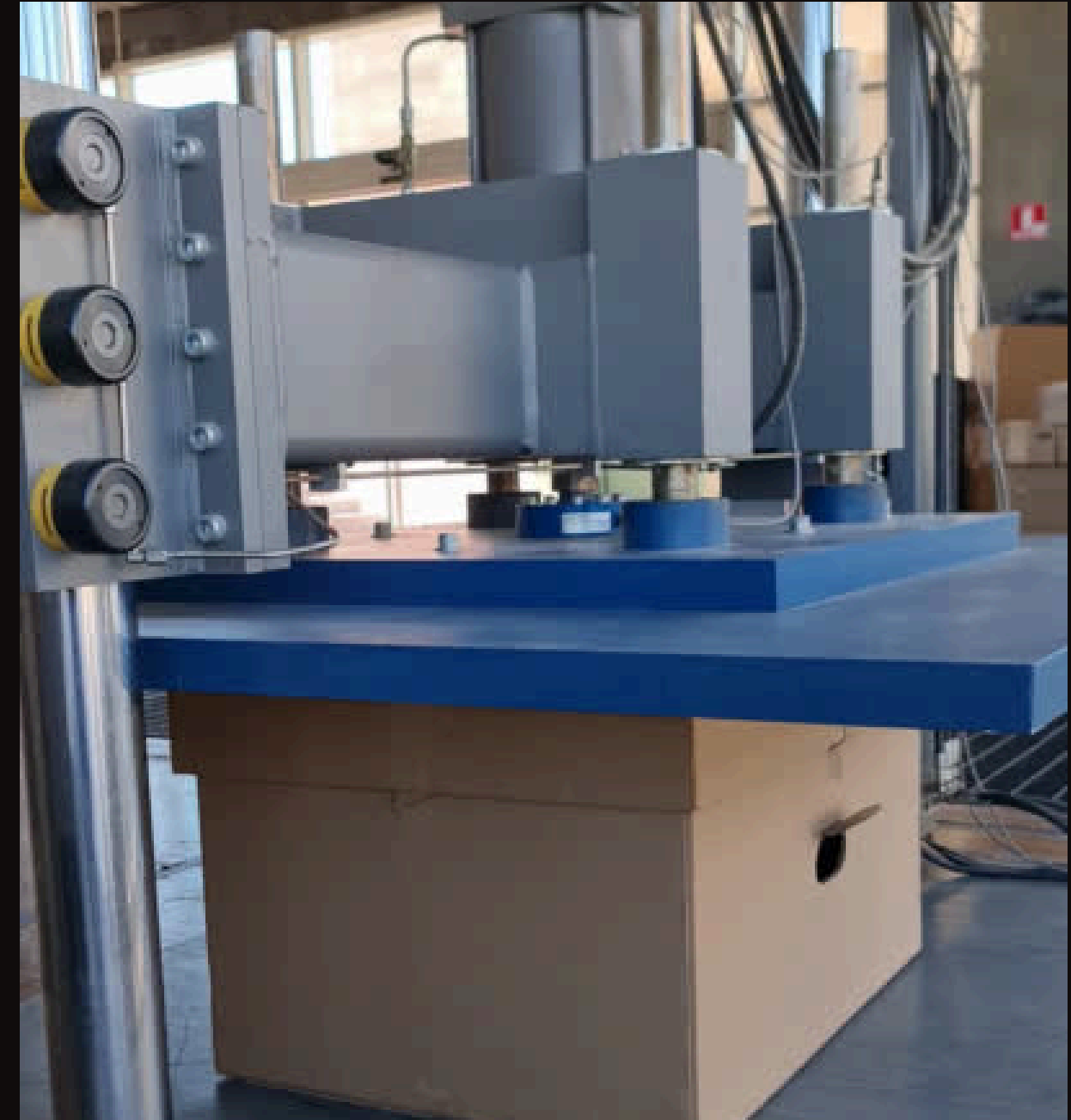
ENG. ELISA MEDINA

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



4

**MECHANICAL
STRUCTURE
ANALYSIS OF THE
MULTI-PMT
SENSOR**



ENG. ELISA MEDINA



4

MECHANICAL STRUCTURE ANALYSIS OF THE MULTI-PMT SENSOR



ENG. ELISA MEDINA



4



ENG. ELISA MEDINA

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



5 UNIVERSITIES IN THE COLLABORATION



Tecnológico
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6 MOU WITH THE UNIVERSITY OF TOKYO



東京大学
THE UNIVERSITY OF TOKYO





**FOLLOW US IN
OUR SOCIAL
MEDIA**

**OUTREACH
HYPER-KAMIOKANDE
MEXICO**

Photo obtained from Hyper-Kamiokande gallery.



**THANK YOU
ISVHECRI!**

**OUTREACH
HYPER-KAMIOKANDE
MEXICO**

References:

1. J. Migenda, The hyper-Kamiokande collaboration, Supernova Model Discrimination with Hyper-Kamiokande Astrophys. J. Accepted (2020). arXiv: 2101.05269
2. Cuen-Rochin, S. et al. (2021). Machine Learning Application for Particle Physics: Mexico's Involvement in the Hyper-Kamiokande Observatory. In: Oliva, D., Houssein, E.H., Hinojosa, S. (eds) Metaheuristics in Machine Learning: Theory and Applications. Studies in Computational Intelligence, vol 967. Springer, Cham. https://doi.org/10.1007/978-3-030-70542-8_23
3. The Univ. of Tokyo Kamioka Observatory. Hyper-Kamiokande. 2024. URL: <https://www-sk.icrr.u-tokyo.ac.jp/en/hk/>
4. Proto-Collaboration, H-K et al. Hyper-Kamiokande Design Report. 2018. URL: <https://0-search-ebSCOhost-com.biblioteca-ils.tec.mx/login.aspx?direct=true&db=edsarx&AN=edsarx.1805.04163&lang=es&site=eds-live&scope=site>