

Mexico in HEP

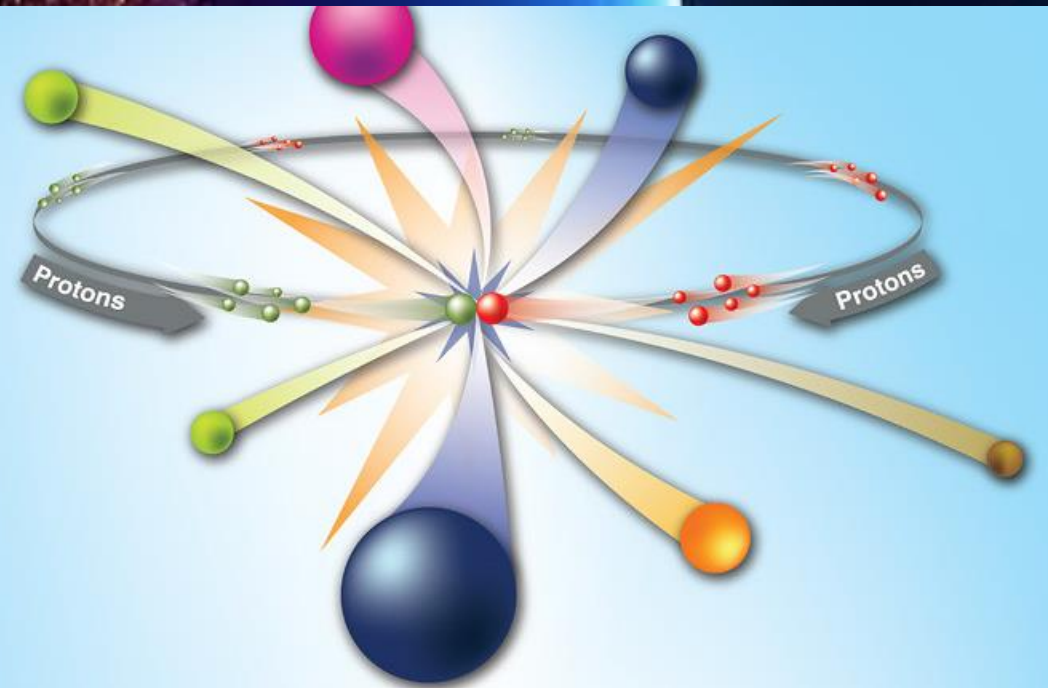
*Latin American Workshop on Software
and Computing challenges in High-
energy Particle Physics*

Alfredo Castaneda
Universidad de Sonora

Ciudad de Mexico, November 20-23th 2019

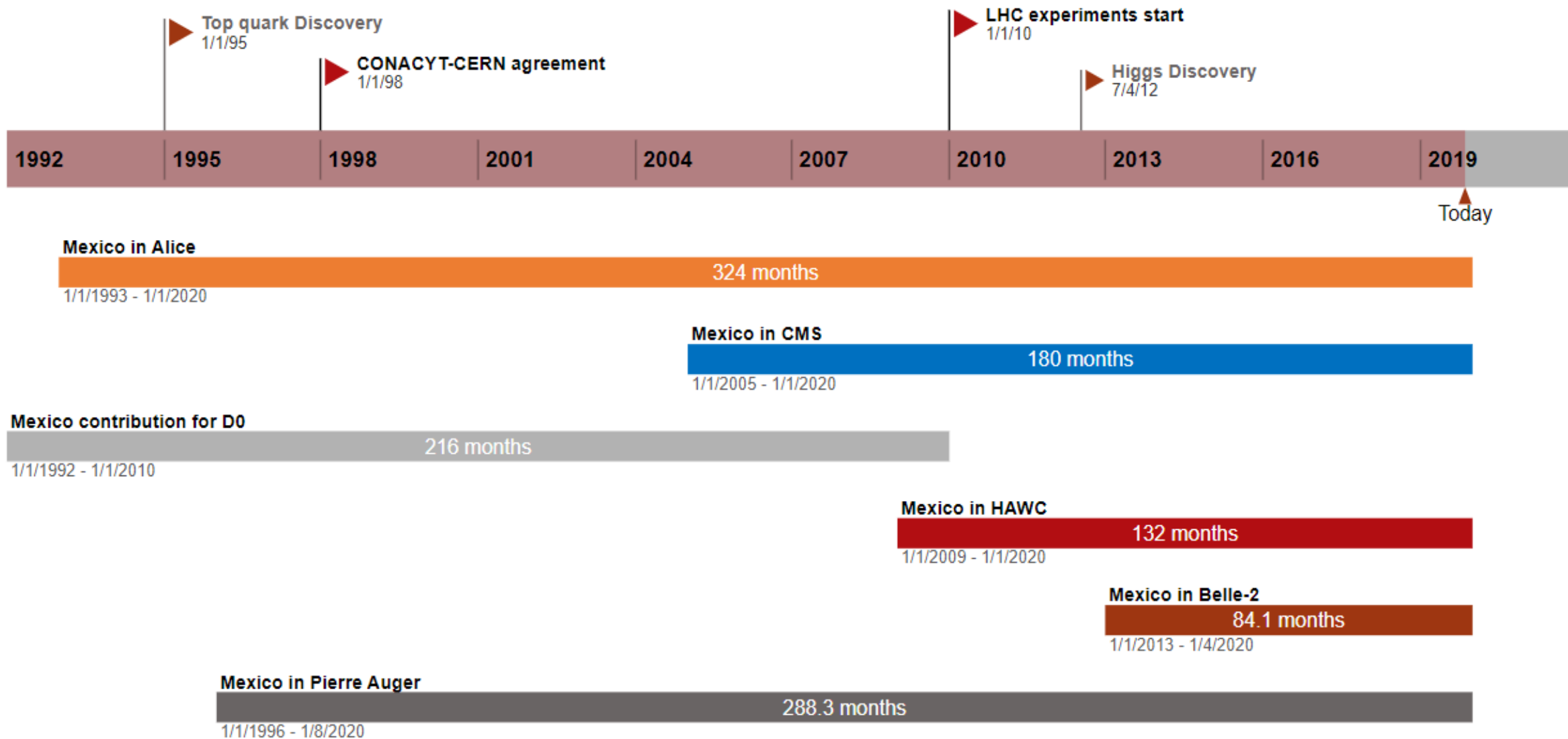
Diversity of Mexican collaboration in HEP experiments

- ▶ Over more than three decades Mexico has participated in all kind of particle physics experiments including: particle colliders, fixed target, astrophysics, among others.
- ▶ Including Major contributions in physics analysis (breakthrough discoveries), detector development and computing
- ▶ With the financial support from universities and grants from the government agencies (CONACYT)

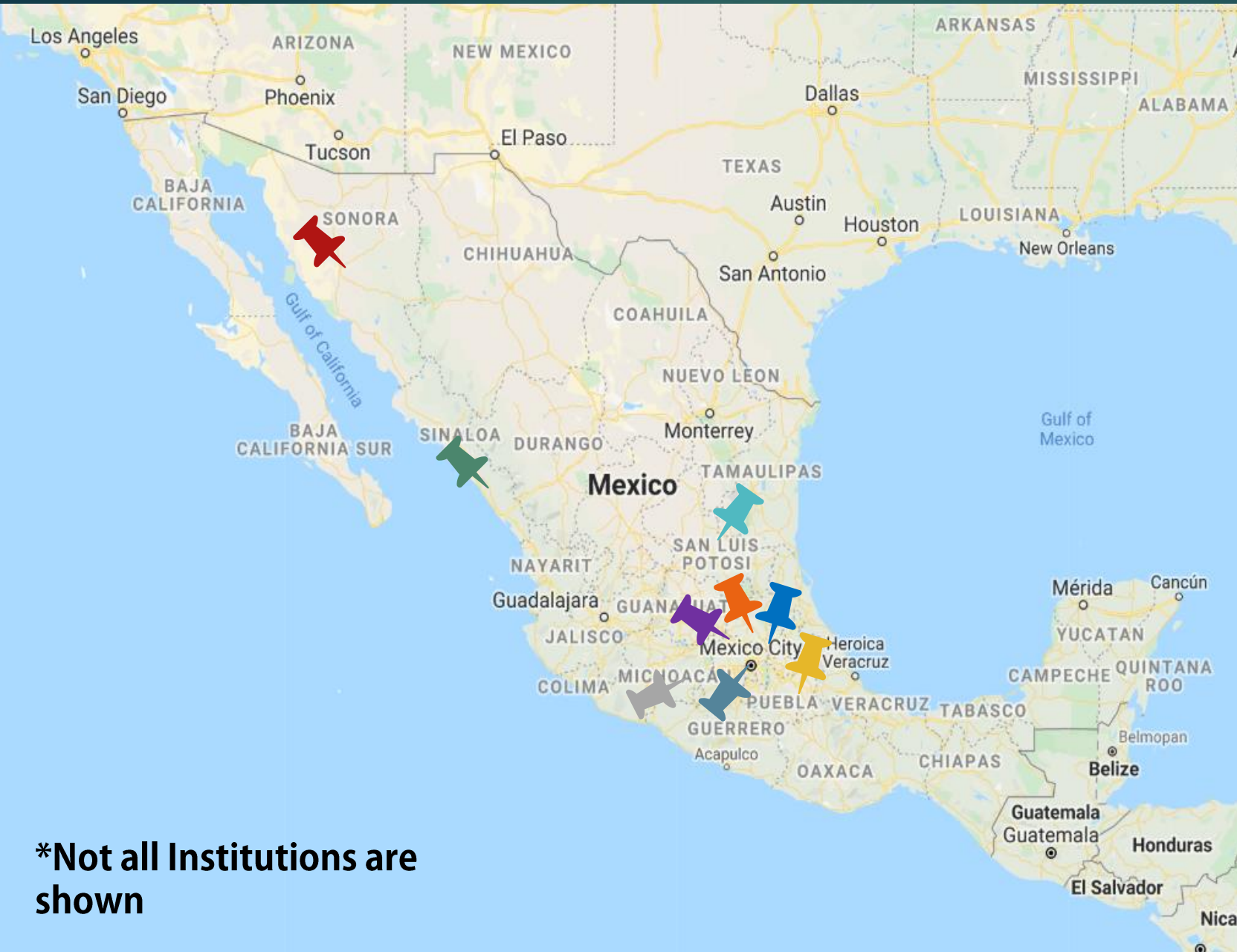


Timeline Mexico in HEP

*Not all experiments shown



Location of institutes participating in HEP



Institucion	Experiment(s)
Autonomous University of Puebla	CMS, Alice, HAWC, Belle-2, Auger, NICA
CINVESTAV	CMS, Alice, HAWC, Belle-2, Auger
Universidad Nacional Autonoma	Alice, HAWC, Belle-2, Auger, NICA
Universidad Iberoamericana	CMS
Universidad de Sonora	CMS
Universidad de Sinaloa	CMS, Belle-2, NICA
Univ. Autonoma de San Luis Potosi	CMS, NA62
Universidad Michoacana	HAWC, Auger
CIC-IPN	HAWC

*Not all Institutions are shown

Participation in breakthrough discoveries



Top Discovery

VOLUME 74, NUMBER 14

PHYSICAL REVIEW LETTERS

3 APRIL 1995

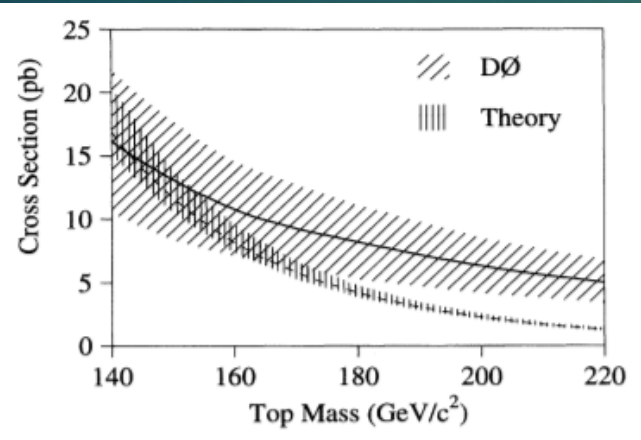
Observation of the Top Quark

S. Abachi,¹² B. Abbott,³³ M. Abolins,²³ B. S. Acharya,⁴⁰ I. Adam,¹⁰ D. L. Adams,³⁴ M. Adams,¹⁵ S. Ahn,¹² H. Aihara,²⁰ J. Alitti,³⁶ G. Álvarez,¹⁶ G. A. Alves,⁸ E. Amidi,²⁷ N. Amos,²² E. W. Anderson,¹⁷ S. H. Aronson,³ R. Astur,³⁸ R. E. Avery,²⁹ A. Baden,²¹ V. Balamurali,³⁰ J. Balderston,¹⁴ B. Baldin,¹² J. Bantly,⁴ J. F. Bartlett,¹² K. Bazizi,⁷ J. Bendich,²⁰ S. B. Beri,³¹ I. Bertram,³⁴ V. A. Bezzubov,³² P. C. Bhat,¹² V. Bhatnagar,³¹ M. Bhattacharjee,¹¹ A. Bischoff,⁷ N. Biswas,³⁰ G. Blazey,¹² S. Blessing,¹³ A. Boehnlein,¹² N. I. Bojko,³² F. Borchering,¹² J. Borders,³⁵ C. Boswell,⁷ A. Brandt,¹² R. Brock,²³ A. Bross,¹² D. Buchholz,²⁹ V. S. Burtovoi,³² J. M. Butler,¹² D. Casey,³⁵ H. Castilla-Valdez,⁹ D. Chakraborty,³⁸ S.-M. Chang,²⁷ S. V. Chekulaev,³² L.-P. Chen,²⁰ W. Chen,³⁸ L. Chevalier,³⁶ S. Chopra,³¹ B. C. Choudhary,⁷ J. H. Christenson,¹² M. Chung,¹⁵ D. Claes,³⁸ A. R. Clark,²⁰ W. G. Cobau,²¹ J. Cochran,⁷ W. E. Cooper,¹² C. Cretsinger,³⁵ D. Cullen-Vidal,⁴ M. Cummings,¹⁴ D. Cutts,⁴ O. I. Dahl,²⁰ K. De,⁴¹ M. Demarteau,¹² R. Demina,²⁷ K. Denisenko,¹² N. Denisenko,¹² D. Denisov,¹² S. P. Denisov,³² W. Dharmaratna,¹³ H. T. Diehl,¹² M. Diesburg,¹² G. Di Loreto,²³ R. Dixon,¹² P. Draper,⁴¹ J. Drinkard,⁶ Y. Ducros,³⁶ S. R. Dugad,⁴⁰ S. Durston-Johnson,³⁵ D. Edmunds,²³ A. O. Efimov,³² J. Ellison,⁷ V. D. Elvira,^{12,*} R. Engelmann,³⁸ S. Eno,²¹ G. Eppley,³⁴ P. Ermolov,²⁴ O. V. Eroshin,³² V. N. Evdokimov,³² S. Fahey,²³ T. Fahland,⁴ M. Fatyga,³ M. K. Fatyga,³⁵ J. Featherly,³ S. Feher,³⁸ D. Fein,² T. Ferbel,³⁵ G. Finocchiaro,³⁸ H. E. Fisk,¹² Yu. Fisyak,²⁴ E. Flattum,²³ G. E. Forden,² M. Fortner,²⁸ K. C. Frame,²³ P. Franzini,¹⁰ S. Fredriksen,³⁹ S. Fuess,¹² A. N. Galiayev,³² E. Gallas,⁴¹ C. S. Gao,^{12,†} S. Gao,^{12,†} T. L. Geld,²³ R. J. Genik,^{12,‡}

¹University of California, Riverside, California 92521
⁸LAFEX, Centro Brasileiro de Pesquisas Físicas, Rio de Janeiro, Brazil
⁹Centro de Investigacion y de Estudios Avanzados, Mexico City, Mexico
¹⁰Columbia University, New York, New York 10027

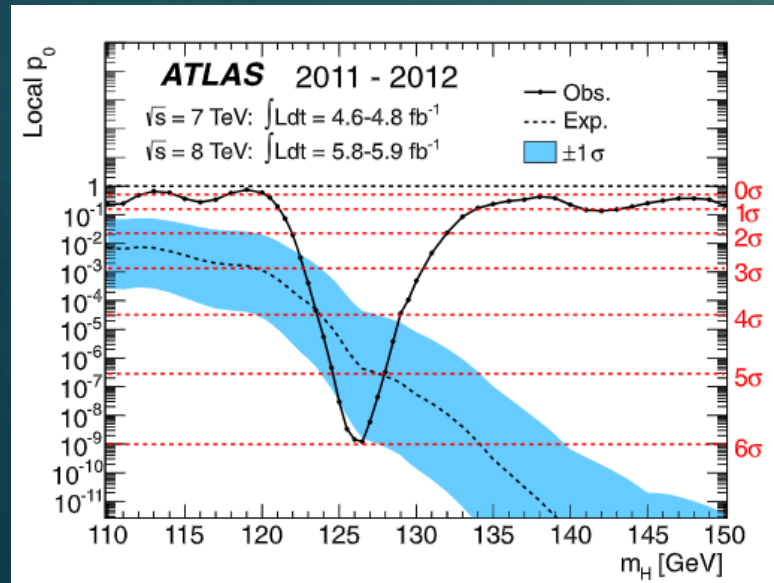
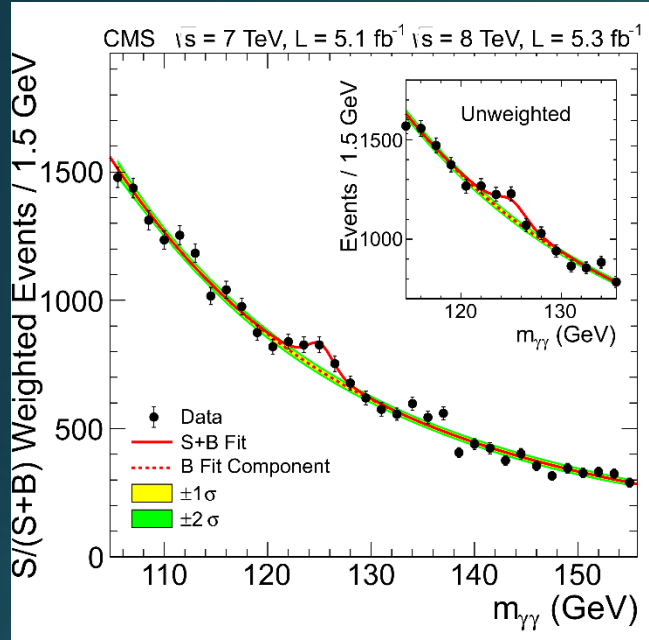
CINVESTAV

Heriberto Castilla (Leader of the Dzero Mexican collaboration)



Higgs Discovery (2012)

CMS-Mexico



Physics Letters B 716 (2012) 30–61

Contents lists available at SciVerse ScienceDirect

ELSEVIER

Physics Letters B

www.elsevier.com/locate/physletb

Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC[☆]

CMS Collaboration^{*}

CERN, Switzerland
This paper is dedicated to the memory of our colleagues who worked on CMS but have since passed away. In recognition of their many contributions to the achievement of this observation.

H. Castilla-Valdez, E. De La Cruz-Burelo, I. Heredia-de La Cruz, R. Lopez-Fernandez, R. Magaña Villalba, J. Martínez-Ortega, A. Sánchez-Hernández, L.M. Villaseñor-Cendejas

Centro de Investigación y de Estudios Avanzados del IPN, Mexico City, Mexico

S. Carrillo Moreno, F. Vazquez Valencia

Universidad Iberoamericana, Mexico City, Mexico

H.A. Salazar Ibarguen

Benemerita Universidad Autónoma de Puebla, Puebla, Mexico

E. Casimiro Linares, A. Morelos Pineda, M.A. Reyes-Santos

Universidad Autónoma de San Luis Potosí, San Luis Potosí, Mexico

ATLAS (Mexican working for foreign institutes)

Physics Letters B 716 (2012) 1–29

Contents lists available at SciVerse ScienceDirect

ELSEVIER

Physics Letters B

www.elsevier.com/locate/physletb

Observation of a new particle in the search for the Standard Model Higgs boson with the ATLAS detector at the LHC[☆]

ATLAS Collaboration^{*}
This paper is dedicated to the memory of our ATLAS colleagues who did not live to see the full impact and significance of their contributions to the experiment.

A.M. Castaneda Hernandez^{173,i}, E. Castaneda-Miranda¹⁷³, M.I. Pedraza Morales¹⁷³

¹⁷³ Department of Physics, University of Wisconsin, Madison, WI, United States

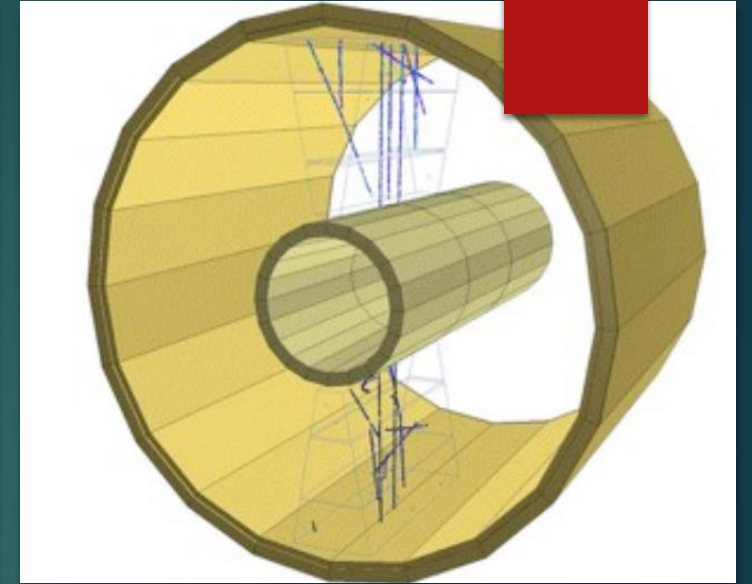
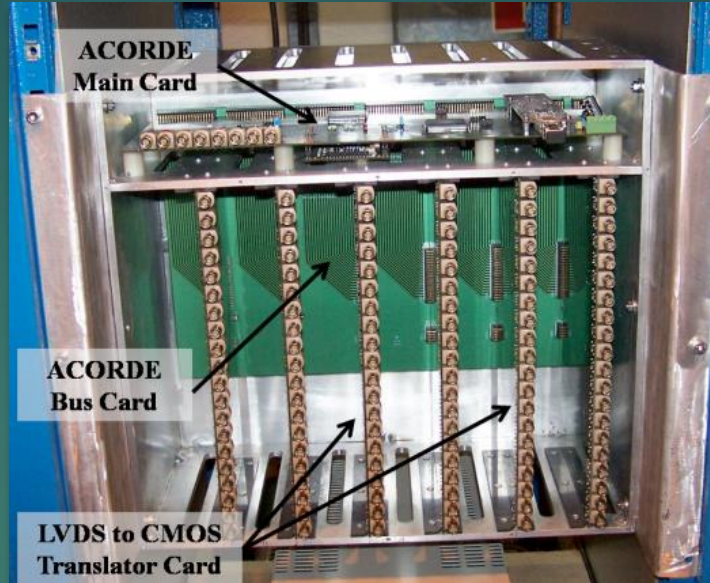
Participation in detector developments



ALICE

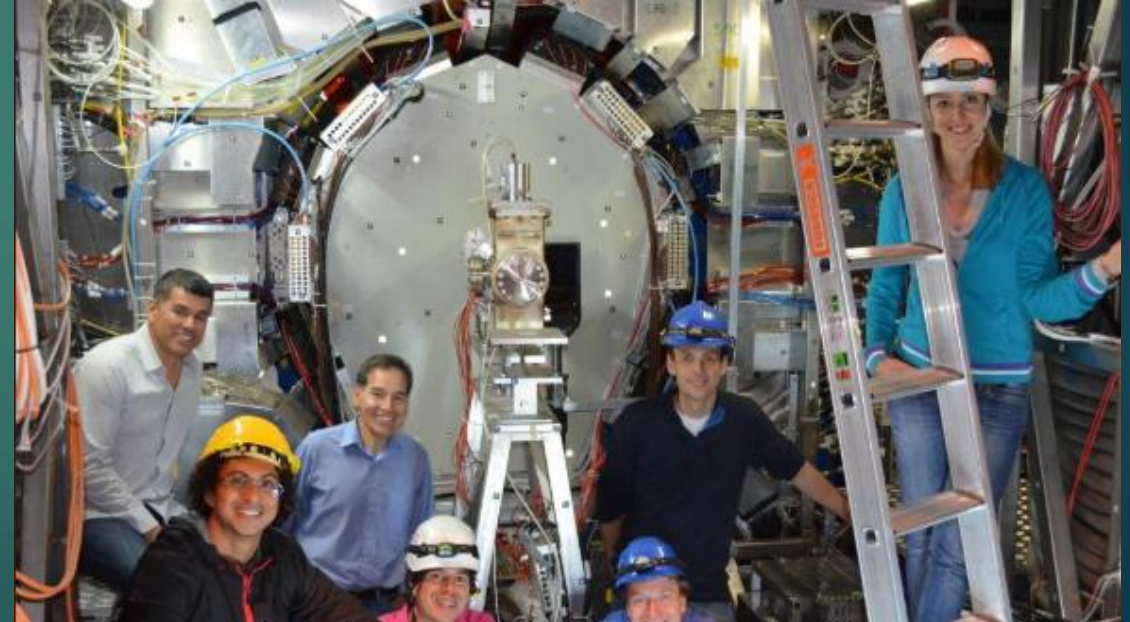
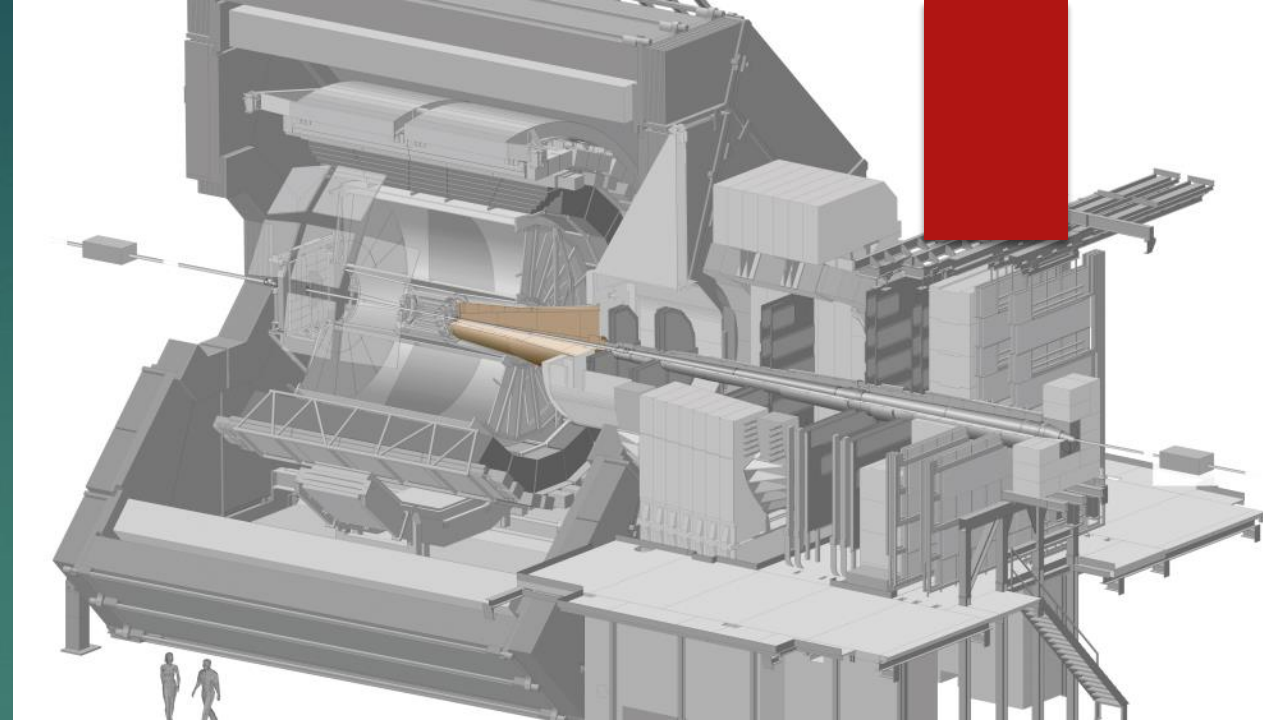
ACORDE detector for ALICE

- ▶ Mexico contributed for the construction of the ALICE Cosmic ray detector (ACORDE)
- ▶ The Dr. Arturo Fernandez Tellez (bottom right) from Autonomous University of Puebla coordinated the effort
- ▶ It consists of an array of plastic scintillator placed in the three upper faces of the magnet
- ▶ The purpose of the detector was to act as a cosmic ray trigger for ALICE and collect data to study high energy cosmic rays



V0 detector for ALICE

- ▶ Small angle detector consisting of two arrays of 32 scintillator counters
- ▶ Provides Minimum Bias trigger and centrality trigger for the central barrel detectors in pp and A-A collisions
- ▶ France and Mexico participated in the construction, maintenance and operations



Ildefonso Leon Monzon (Universidad de Sinaloa)

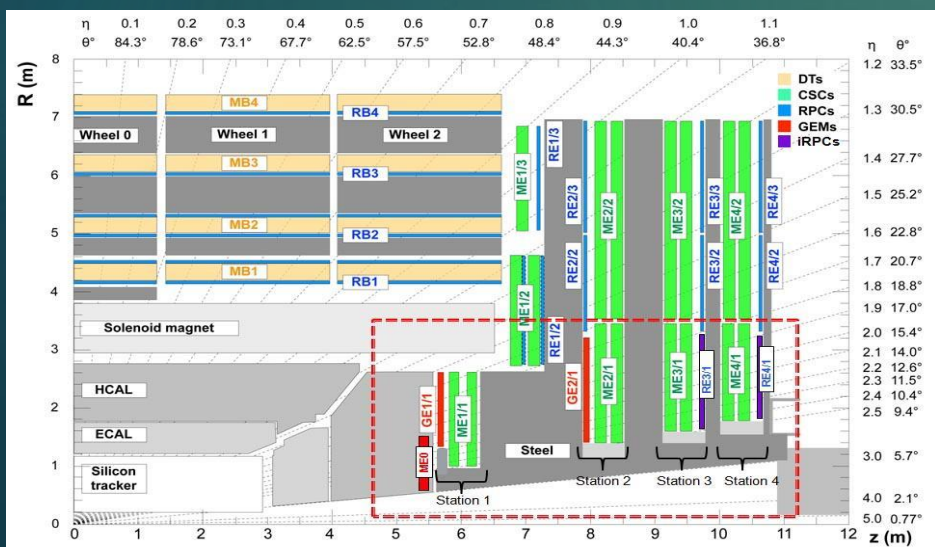
Gerardo Herrera Corral (CINVESTAV)



Contributions for the RPC system in CMS

GIF++ at CERN

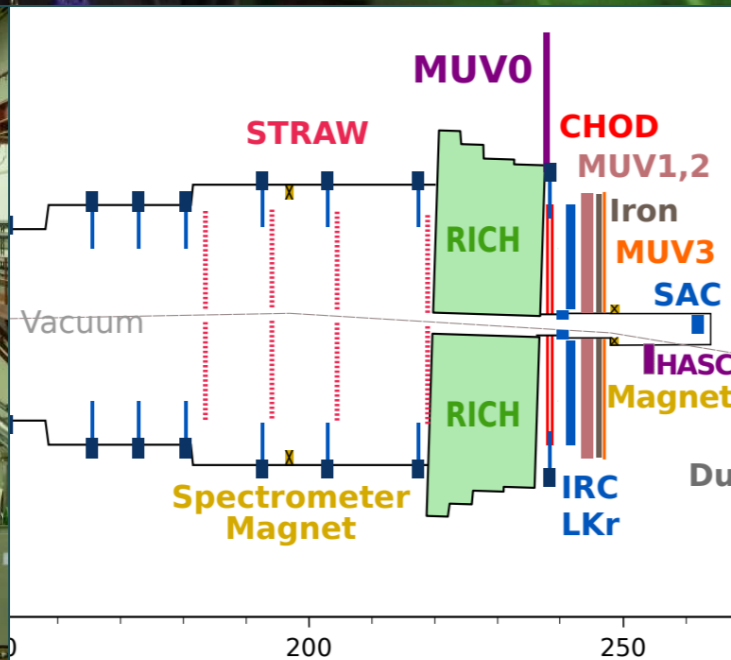
- Common effort from Ibero, Cinvestav, Puebla
- Since 2015 contributed to Longevity studies for the upgrade of the RPC system during Phase-2
- Salvador Carrillo (Ibero) was GIF++ and Test beam coordinator during 2016-2017
- Isabel Pedraza (Puebla) is the upgrade coordinator for the RPC system
- CMS chamber production Responsible for Phase-2 (2018-2020)





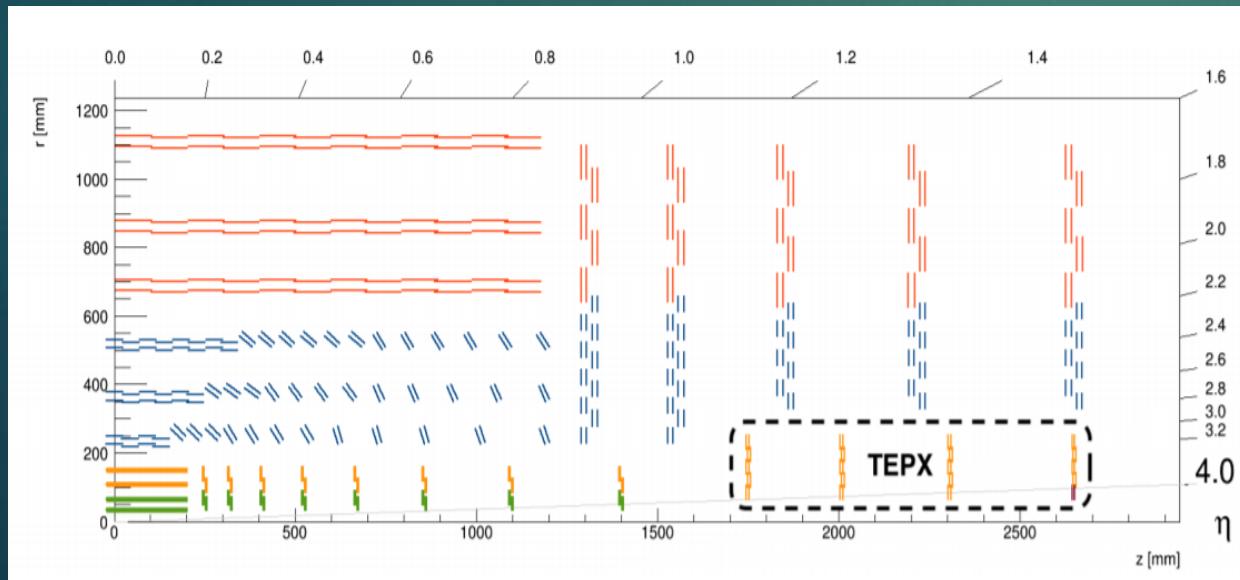
Contributions for the NA62 experiment

- ▶ Experiment designed to measure the very rare kaon decay $K^+ \rightarrow \pi^+ \nu \bar{\nu}$ at the CERN SPS
- ▶ Sensitive to searches for the dark photon (invisible decay)
- ▶ With participation from faculty and students from Universidad de San Luis Potosi
- ▶ Jurgen Engelfried (Universidad de San Luis Potosi) is the Data Quality coordinator
- ▶ Contribution to the development of RICH detectors



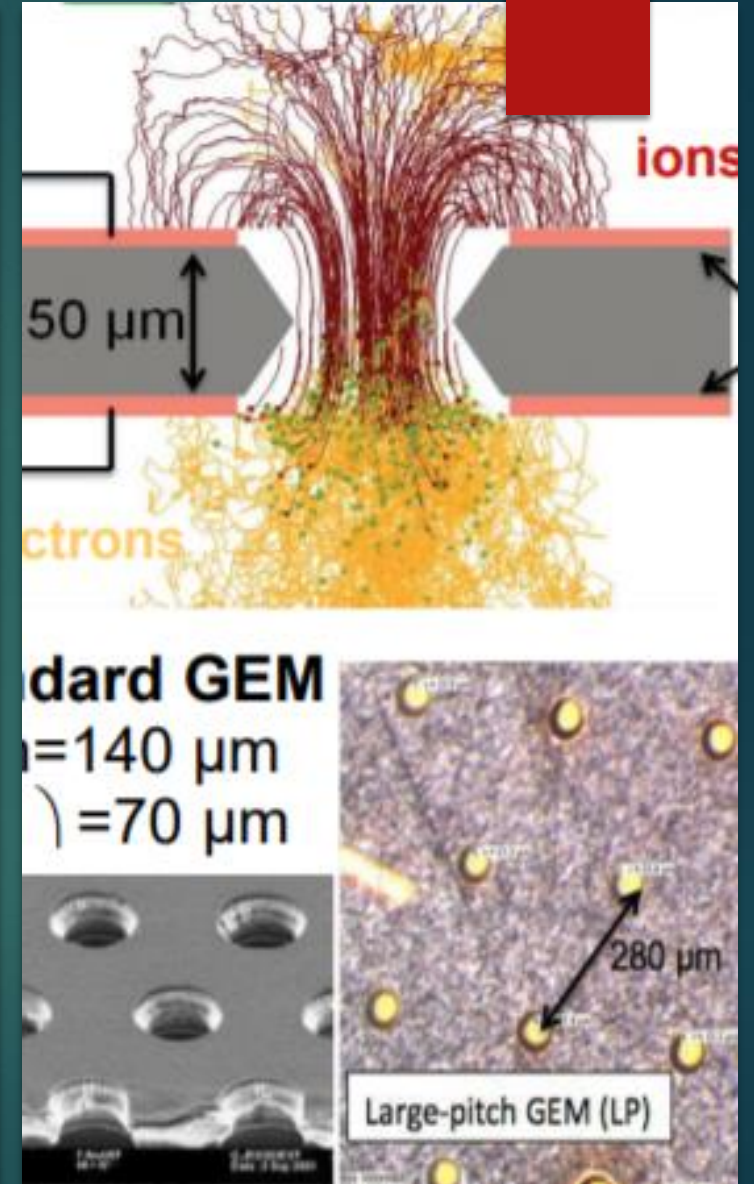
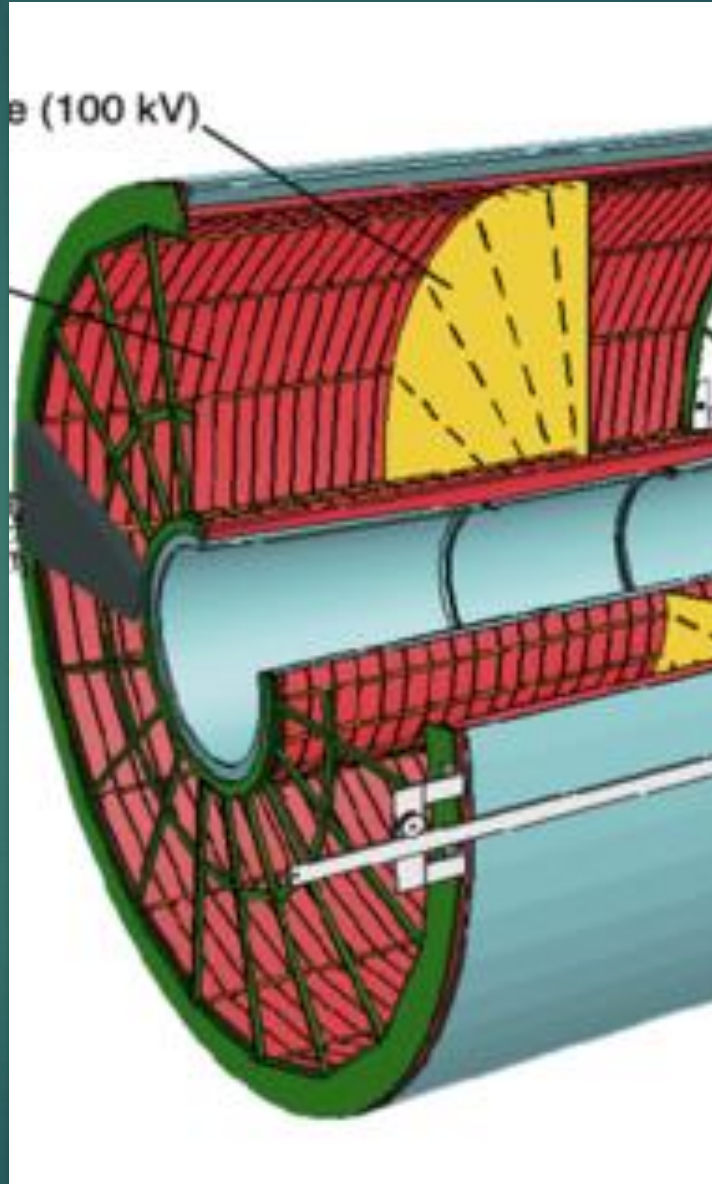
Contributions for the BRIL project in CMS

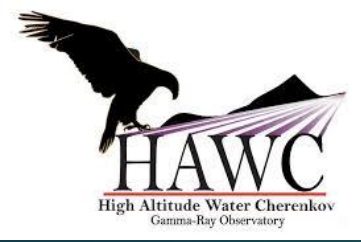
- Beam Radiation Integrated Luminosity (BRIL) project is a collection of detectors located near the collision point at the CMS experiment
- Designed to measure luminosity and radiation doses
- Mexico contributes with simulation studies and performance for Phase-2 upgrades
- TPEX system is an extension of the pixel detector that will allow a better determination of luminosity
- Universidad de Sonora will contribute to the R&D studies, Test Beam exercises and electronics (FPGA programming)



Upgrade of the TPC in ALICE

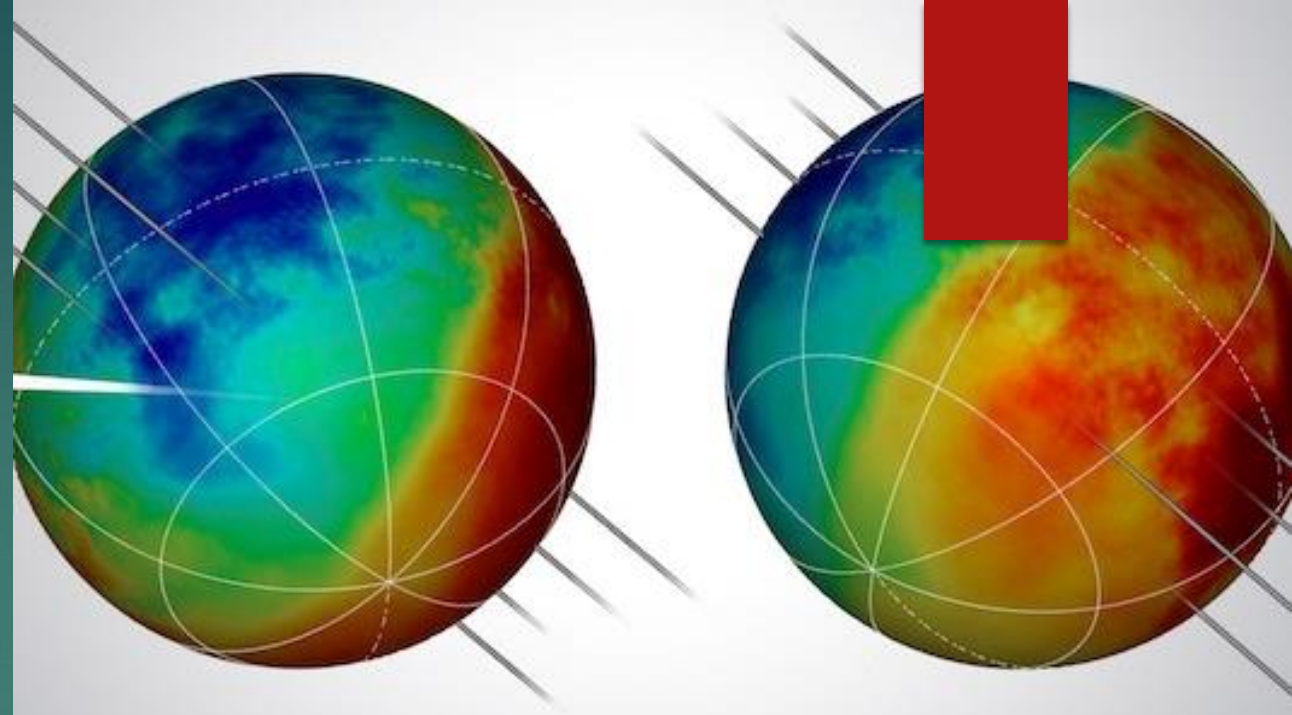
- ▶ ALICE experiment will contribute to the upgrade of the TPC detector at ALICE
- ▶ Integration of GEM technology to afford the increase rate of particles
- ▶ Universidad Nacional Autonoma (UNAM) perform studies at the lab to test the new technology





HAWC experiment

- ▶ 13 Mexican institutions participating <https://www.hawc-observatory.org/collaboration/>
- ▶ HAWC is located on the flanks of the Sierra Negra volcano near Puebla at an altitude of 4100 meters
- ▶ HAWC is a facility designed to observe gamma rays and cosmic rays between 100 GeV and 100 TeV
- ▶ HAWC construction leaded by scientists from USA and Mexico
- ▶ Principal role of Mexican scientist:
 - ▶ Dr. Andres Sandoval (UNAM), Spokeperson (Mexico)
 - ▶ Dr. Alberto Carraminana (UNAM), Science coordinator
 - ▶ Dr. Ibrahim Torres (INAOE), on place coordinator at the observatory



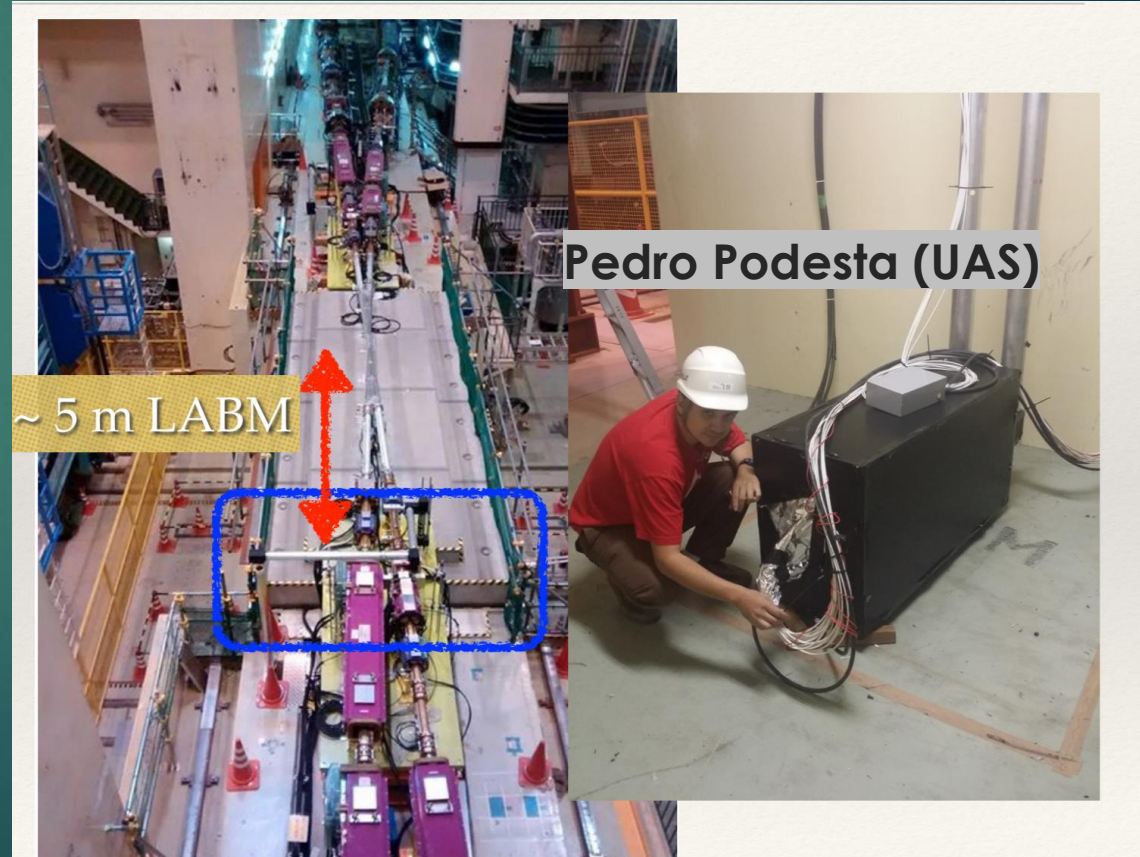
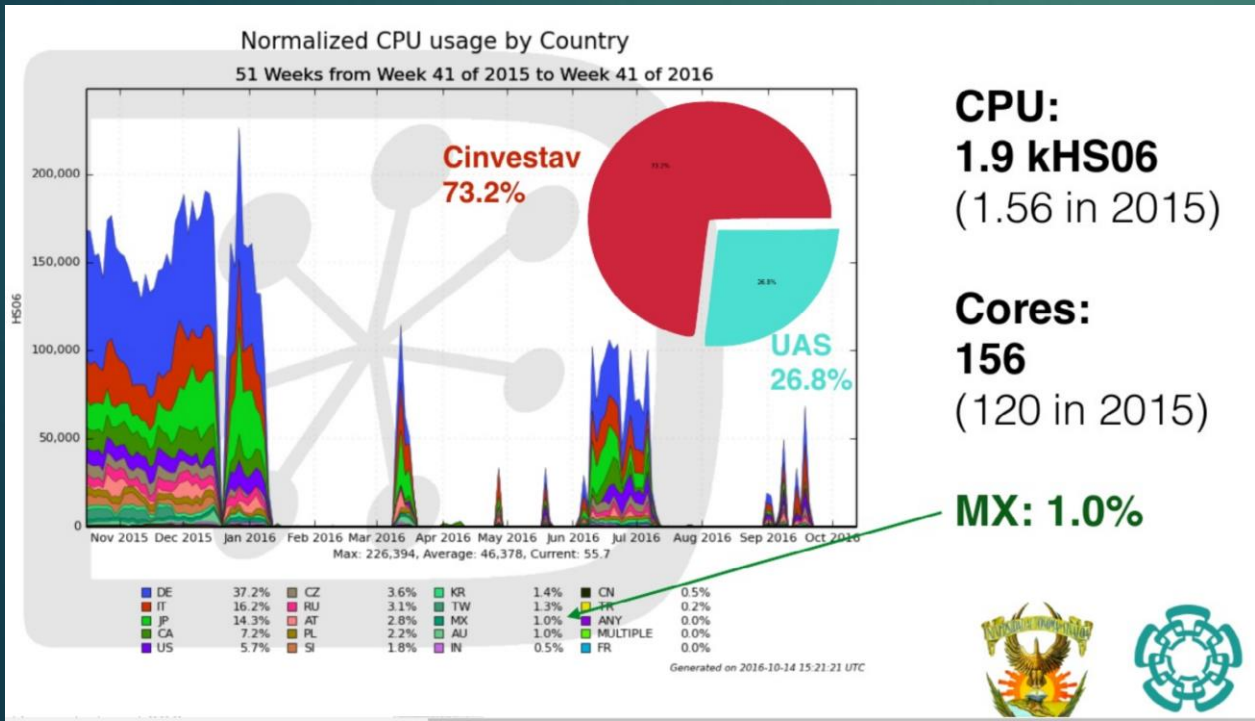


Mexico in Belle-2

- Belle-II will test SM on the next level with 50 ab-1 (x50 Belle data)

Large Angle Bremsstrahlung Monitor (LABM)
Electronics done in Mexico

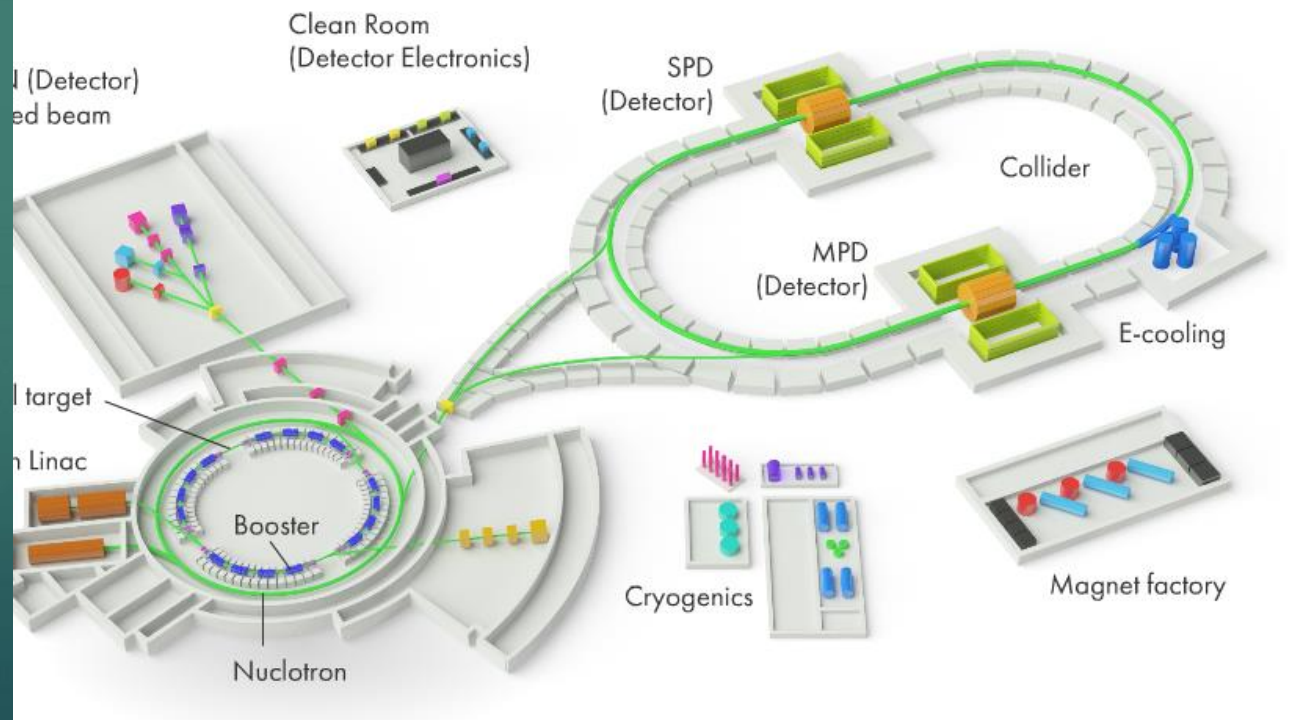
UAS and CINVESTAV
contributing with computing





Mexico in NICA

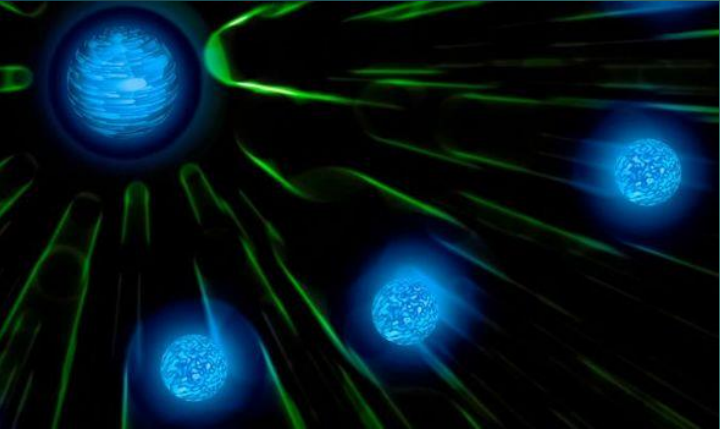
- ▶ Nuclotron-based Ion Collider Facility is implemented at the Joint Institute for Nuclear Research (JINR) located in Russia.
- ▶ Memorandum of understanding between JINR and research institutes of Mexico
- ▶ Mexico will participate on the construction of a detector that would study the intensity of the interacting beams
- ▶ Jose Alejandro Ayala (UNAM) leading the effort of the Mexican scientists participating in NICA



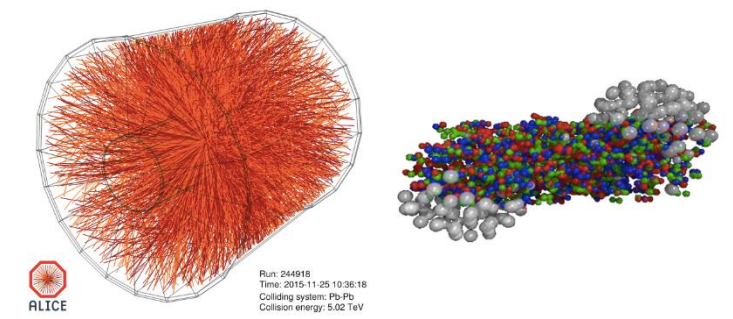
Contributions to physics analysis

Mexico participation in the Hunting for new physics phenomena

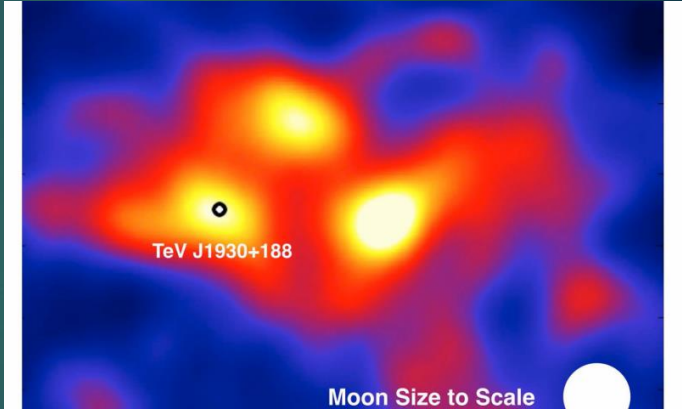
Hunting for Dark matter



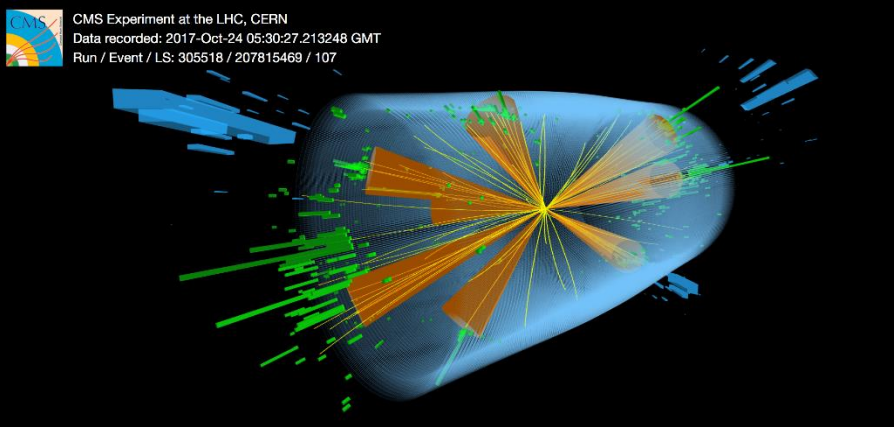
QGP effects



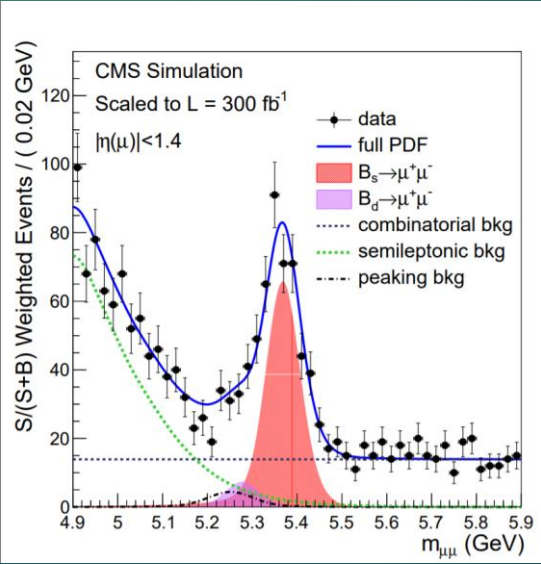
Cosmic ray studies



Higgs properties



Precise B-physics studies



Searching for new physics phenomena


Institucion	Signature	Institution
Dark matter searches (Collider)	Dark sector particles: Dark photon, dark Z, dark Higgs	Sonora, UAS, CINVESTAV
Dark matter searches (Indirect detection)	Product of Annihilation	UNAM, INAOE
Higgs properties	Rare processes: tH, BSM Higgs	Universidad de Sonora, BUAP
B-physics studies	Rare B decays	CINVESTAV, UAS
QGP effects	Quarkonia production in QGP	UNAM, CINVESTAV, Sinaloa
Cosmic Rays	TeV scale cosmic rays	UNAM, Michoacam, CIC, Guadalajara

Relevant contributions to B-physics

- CINVESTAV group has more than 20 years of experience on b-physics analysis, first with D0 at Fermilab now with CMS
- Alberto Sanchez is the first Mexican to give a seminar at CERN
- The seminar “Recent CMS measurements on B_c and B_s spectroscopy” represent the work of students and researchers from CINVESTAV group
- The observation of those new states have been published in important journals as PRL



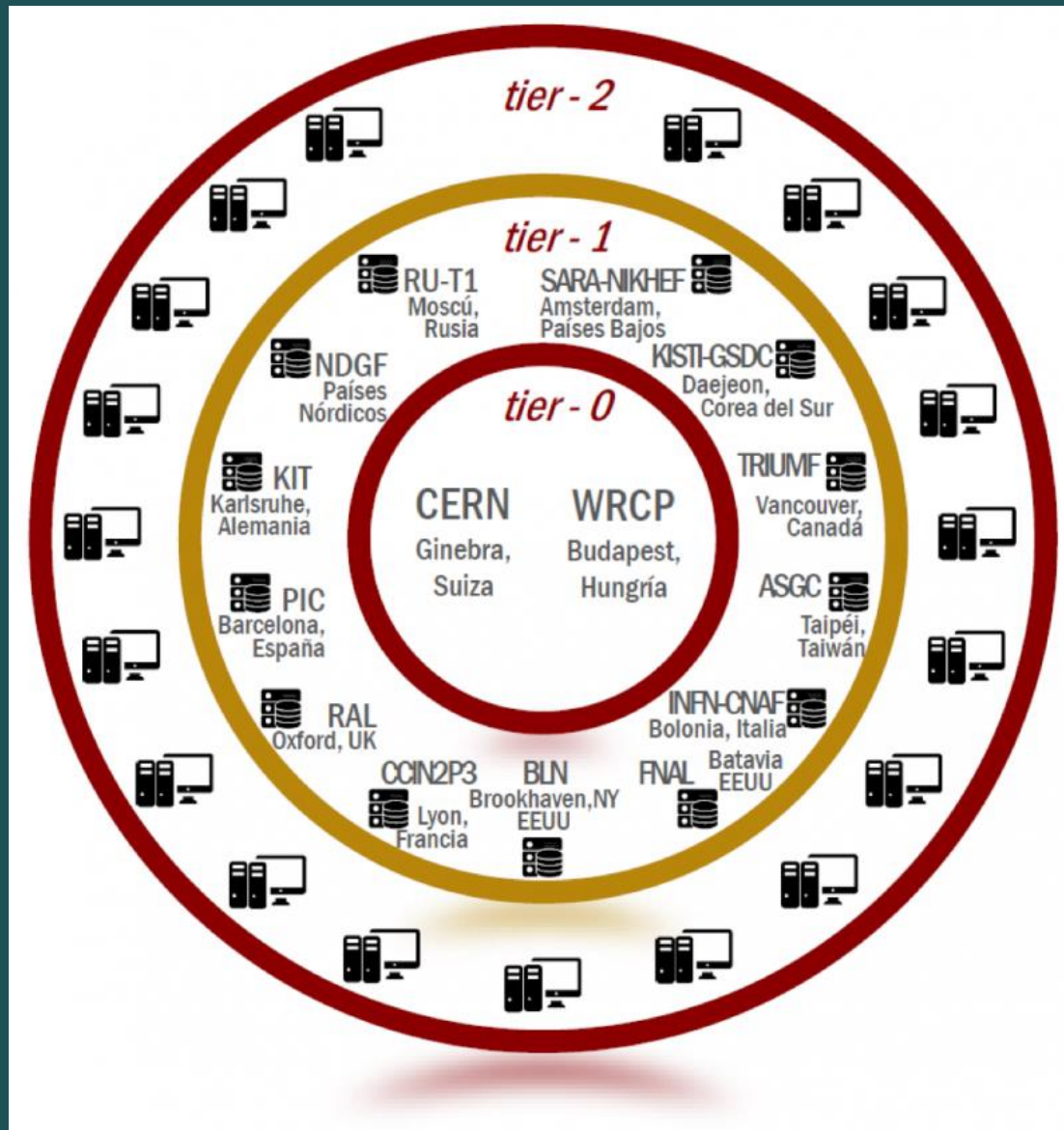
Computing, GRID, New technologies

- 
- ▶ Mexico has proven its impact on detector development and physics analysis
 - ▶ New technologies and volumes of data require resources for data storage, processing and analyzing
 - ▶ Mexico commitment is to contribute to the collaboration to provide computing resources to success on the next physics goals
 - ▶ High Performance Computing and Artificial Intelligence are two areas of development in the coming years

Worldwide LHC Computing Grid 2019

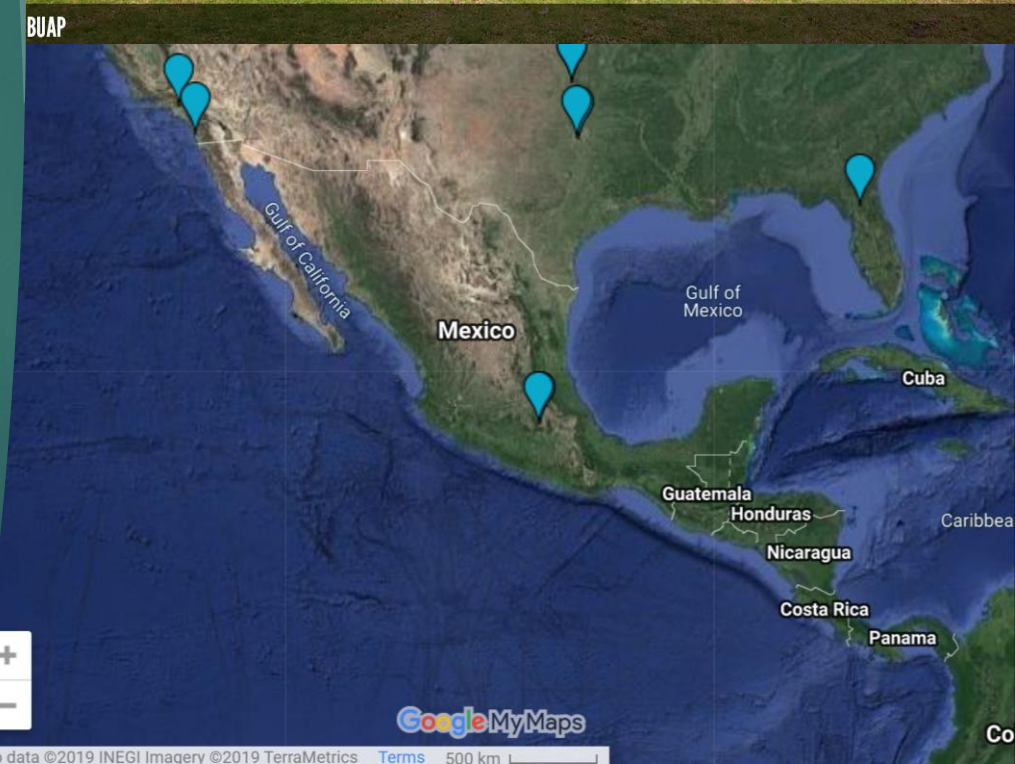
- ▶ Global computing resources to store, distribute and analyze data (~50-70 pb) expected each year
- ▶ Divided into 3 Tier systems: Tier-0, Tier-1, Tier-3 each with various responsibilities
- ▶ CERN has a Tier-0 that has the responsibility to store, process (reconstruction) and distributed data





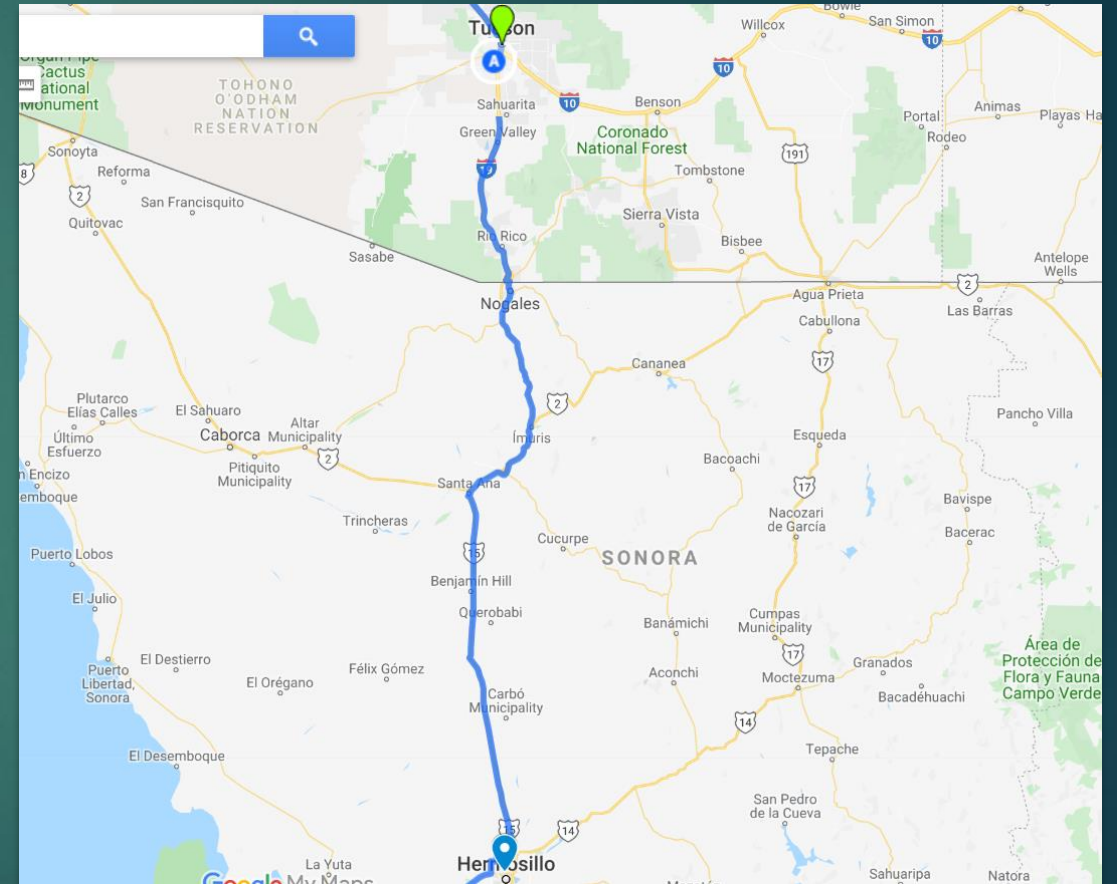
Mexico contributions to the GRID

- ▶ Mexico contributes with a Tier-2 center located in Universidad Autonoma de Mexico
- ▶ The Tier-2 Center started operations in 2014 with a MOU signed between CERN and UNAM
- ▶ There is interest to have additional Tier-2 centers operational
- ▶ The Laboratorio Nacional de Supercomputo (LNS) has all requirements to become the 2nd Mexican Tier-2 center,
- ▶ LNS is located at Puebla



High speed connectivity

- ▶ To be competitive in computing resources in addition to hardware the data transferring rate is essential
- ▶ Currently in Mexico we are limited by the low speed services provided by companies
- ▶ By connecting Mexican institutions with US centers (with optical fibers) a new window of possibilities will be created
- ▶ Currently there is project to connect Universidad de Sonora with US (Tucson, Arizona) with with several kilometers fiber optics to be used for differnet scientific purposes
- ▶ Once connected this will motivate the creation of a Tier-2 Center at the Norwest of Mexico



Dedicated facilities for AI

- ▶ There are several research centers with the capabilities to run Machine Learning algorithms
 - ▶ LNS (Puebla)
 - ▶ CIC (Mexico City)
 - ▶ Universidad de Sonora
- ▶ Several implementations (online, offline) will require the use of neural networks models to perform different tasks
- ▶ Towards the HL-LHC there are areas of development on integration of machine learning models to perform particle identification, signal vs noise separation, triggering, data quality monitoring, among others.

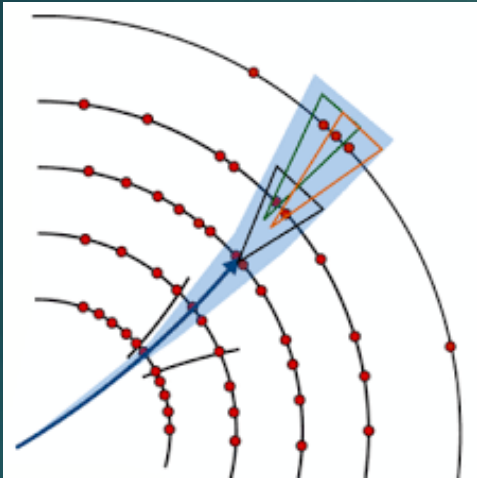


GPU cluster (Sonora)

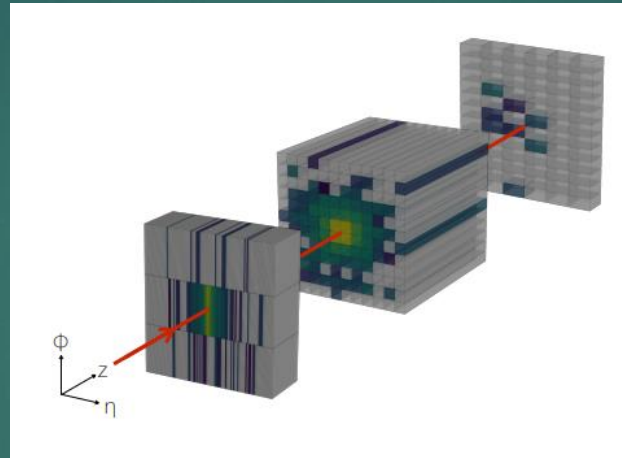


Machine learning applications in HEP

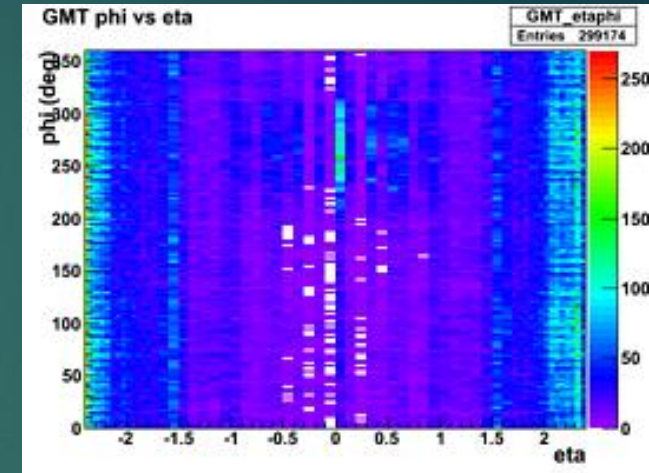
PID, reconstruction
and triggering



Simulation



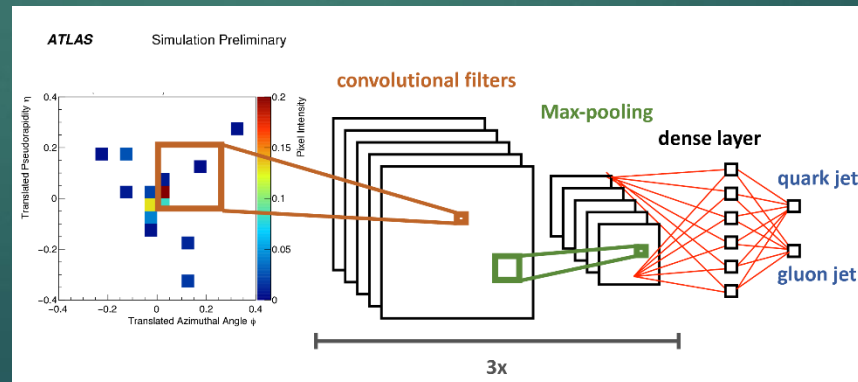
DQM



Hardware triggering



Jet Classification



Overview of ML and Big data Tools

Conclusions

- ▶ Mexico is ready to continue and increase its contributions in HEP experiments
- ▶ Several institutions collaborating in various experiments in the Frontier of Science
- ▶ Looking for further understanding in the universe, searching for new physics phenomena
- ▶ Development of new detector technologies, computing tools
- ▶ Physics analysis looking at:
 - ▶ SM, B-physics
 - ▶ Higgs physics, BSM (Dark matter)
 - ▶ Quark Gluon Plasma physics
 - ▶ Astrophysics , Cosmic rays, neutrino experiments
- ▶ Future look bright but there is plenty of work to do