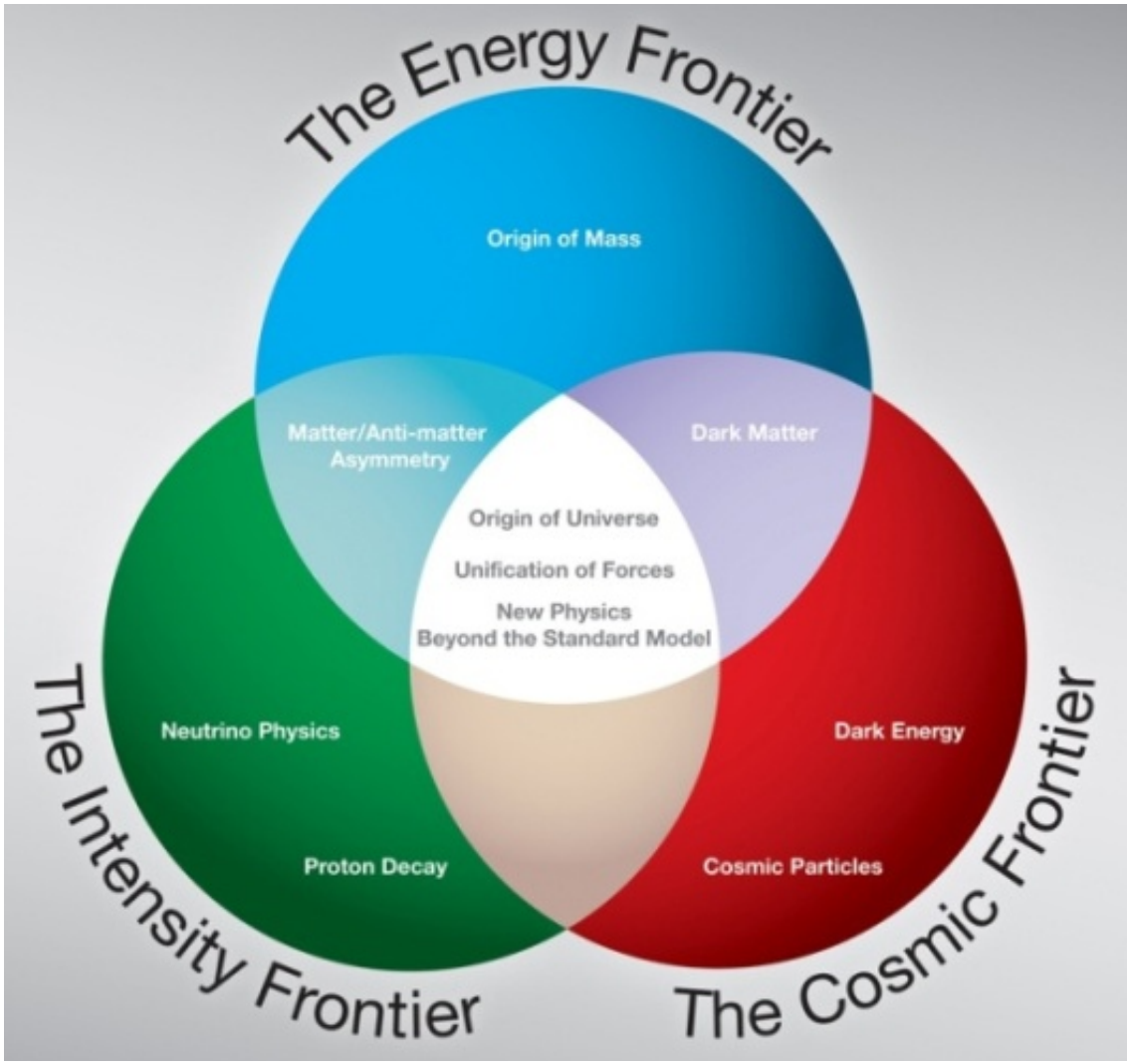
Latin American Participation in Fermilab Experiments and Theoretical Studies

Jorge G. Morfín - Fermilab

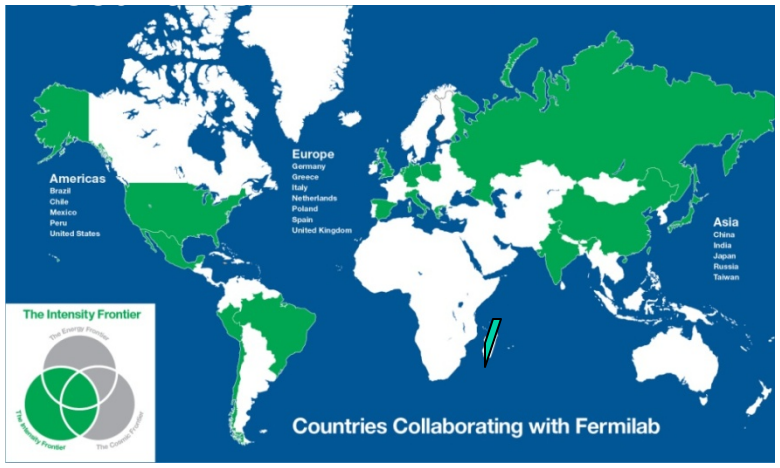
Argonne – U. Chicago – Fermilab Collaboration Meeting

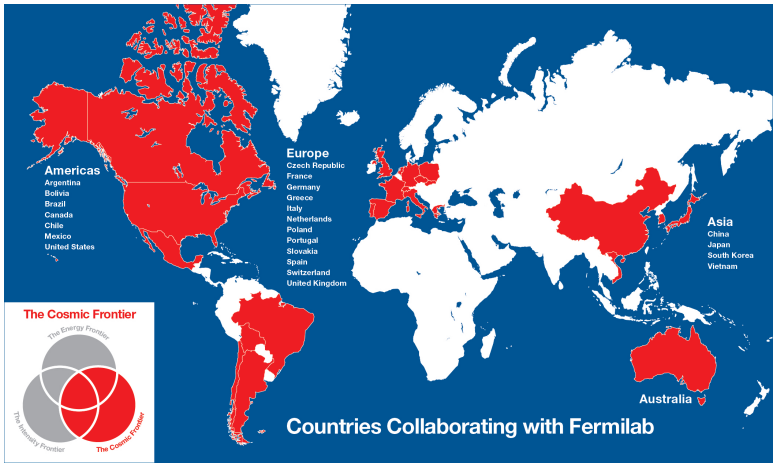
28 May 2013

Frontiers at Fermilab



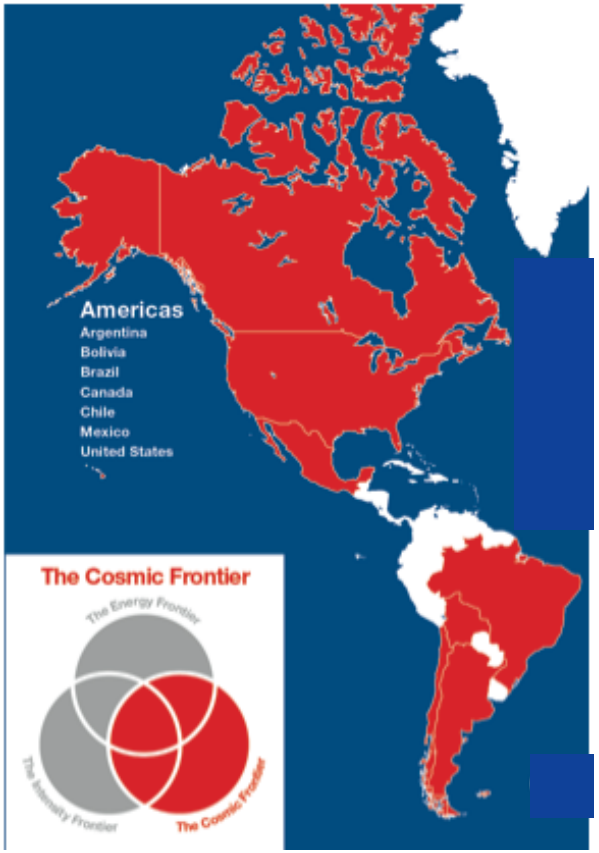
International Collaborations
Experimental Programs at Fermilab





(Latin) American Collaborations

Experimental Programs at Fermilab

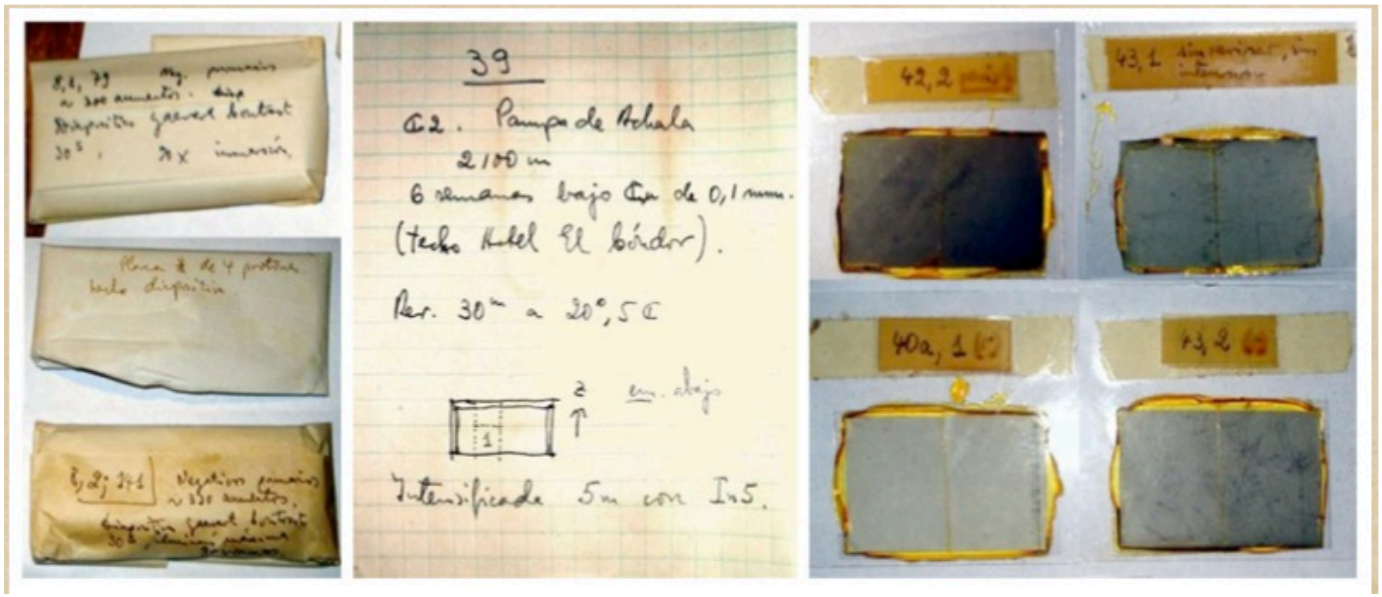


Particle physics in Latin America did not start with Fermilab.

The road to HEP in Latin America

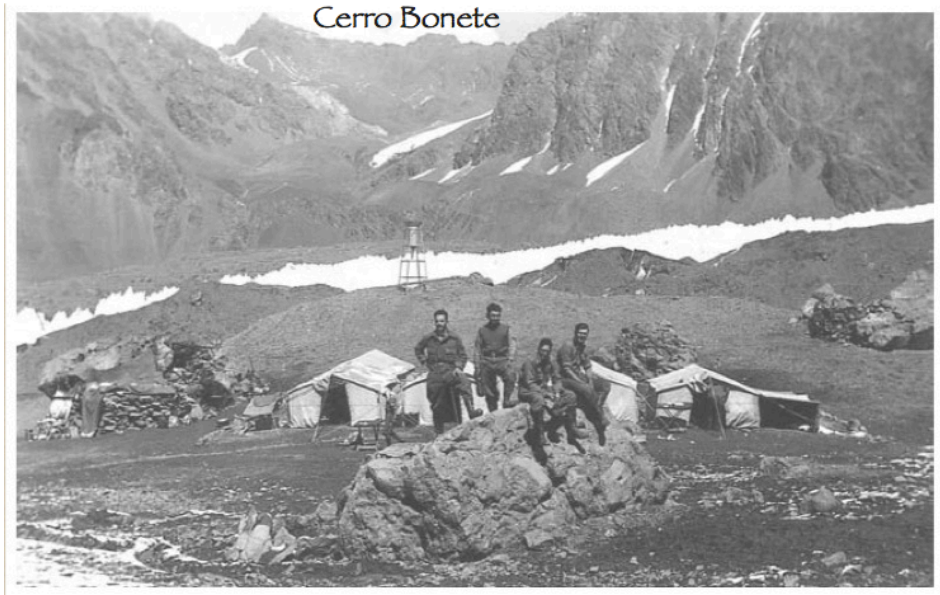
The Road to HEP in Argentina

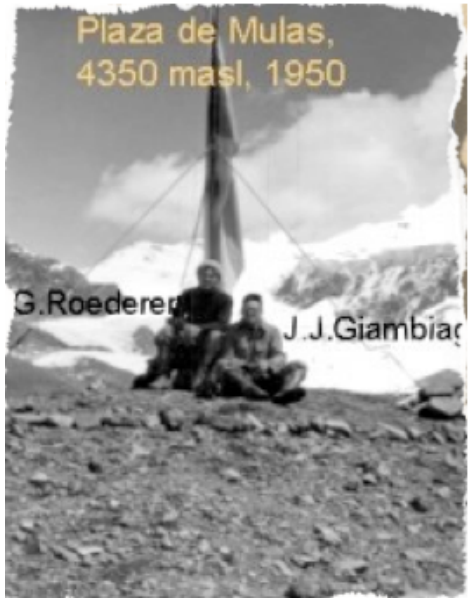
- Early 1930's Louis Leprince-Ringuet & Pierre Auger propose to study the nature of the cosmic rays. The intensity of cosmic rays @ sea level should decrease with latitude due to the earth magnetic field.
- Kodak plate NTA (not nuclear emulsion) – Exposure time: 23 days on "El Condor" - Pampa de Achala - Córdoba province (2108 m) ≈ 1945



The Road to HEP in Argentina

- 1949: Universidad de Buenos Aires a group guided by a teaching assistant Estrella Mathov was created.
- The group was composed of undergraduates Juan Roederer, Beatriz Cougnet, Hans Kobrak and Pedro Waloscheck (Undergrads doing research? Unheard of..)
- Estrella participated in a conference in Brazil about cosmic rays where she met Cecil Powell, Beppo Occhialini and Cesar Lattes.
- 1950 attempts to do measurements at Aconcagua (Plaza de Mulas @ 4325 m)





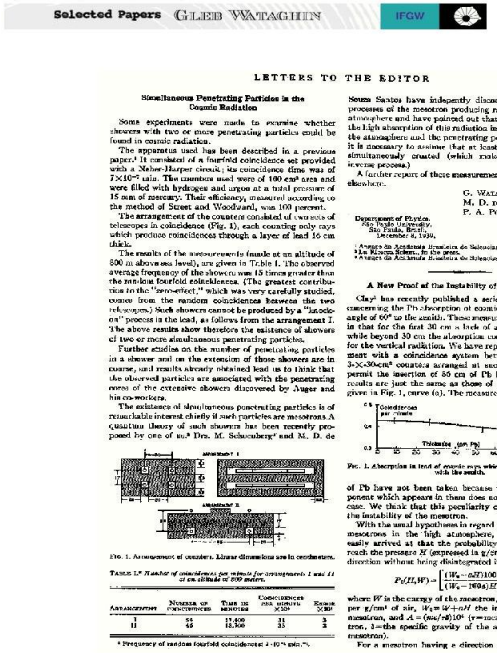
Cosmic Ray Physics to HEP in Argentina

- 1950 Comisión Nacional de Energía Atómica created by Juan Perón
- Creation of the División de Altas Energías
- 1952 Laboratório de Placas Nucleares (CNEA)
- 1952 – 58 Creation of two laboratories:
  - Laboratorio de Partículas Elementales
  - Laboratorio de Radiación Cósmica
- Laboratório de Radiación Cósmica: Worked on the development of muon and neutrons detectors. Also, X-rays and γ-rays detectors to be launched in balloons and rockets.
- "Cosmic Ray" Physics culminating in the Auger Experiment…
- Laboratório de Partículas Elementales: followed its own path and with time, it abandoned cosmic rays as the tool for doing particle physics and went to modern accelerators-→ Fermilab

The Road to HEP in Brasil

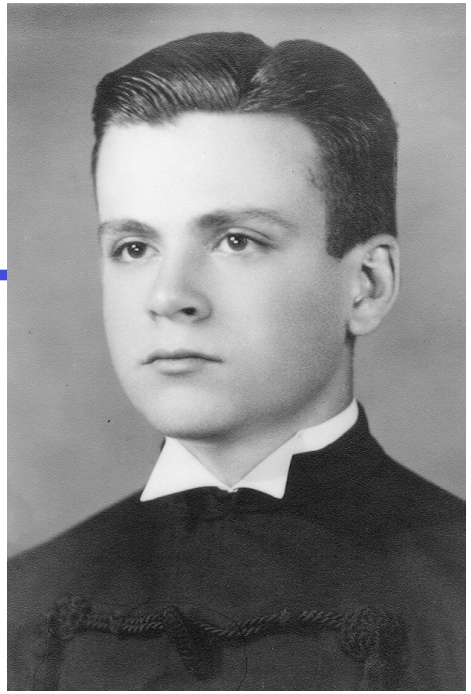
- In the 1930s, physicists Gleb Wathagin ("father of cosmic ray physics in Brazil), Paulus A. Pompeia and Marcelo Damy de Souza Santos did pioneering work at the University of Sao Paulo. Measurements were made in the mine of Morro Velho (Brasil) at depths of 200 and 400 m. w.e. and in São Paulo at a depth of 50 m. w.e.
- First Physical Review paper in 1939: Simultaneous Penetrating Particles in the Cosmic Radiation "

Gleb Wataghin

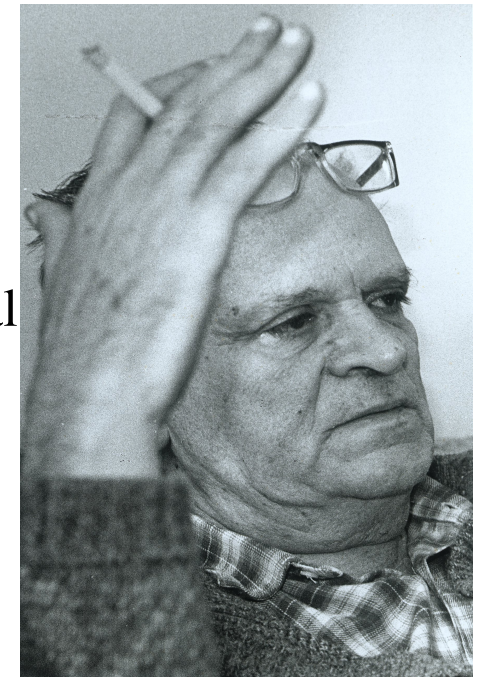


Brasil: Next came Cesar Lattes

Trained as a Theorist



- Asking a young theoretical physicist to calculate a electromagnetic field with a result that consisted of 27 terms....
- **Cesar became an experimentalist!**
- In 1947, Cesar Lattes and G.P.S. Occhialini participated in C.F. Powell's Nobel Prize-winning experiments in the Bolivian Andes, using photographic plates to study the processes leading to the production of secondary particles in cosmic rays **and discovered the pion.**
- In 1949, Lattes founded the *Centro Brazileiro de Pesquisas Fisicas (CBPF)*, a research center devoted to both experimental and theoretical physics. He also used his prestige to fight for the formation of CNPq, the Conselho Nacional de Pesquisas in 1951. Leading to the development of HEP in Brasil -→ Fermilab.

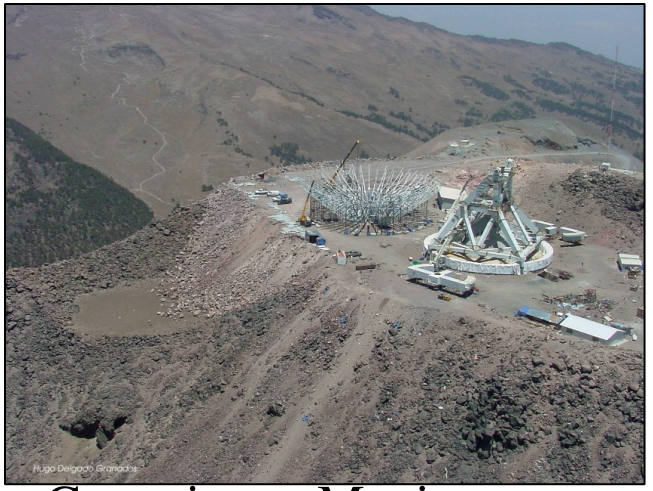


The Road to HEP in Mexico

- FIRST STEPS: **Manuel Sandoval Vallarta., b**orn in Mexico City the 11th of January of 1899.
- After finishing high school in Mexico he entered MIT in USA in 1917, received his PhD in 1924 and was professor there until 1946.
- His interest in cosmic rays started in 1932 and the details of the effect of the geomagnetic field was calculated in a series of papers by Georges Lemaitre (proposer of the Big Bang Theory) and Manuel Sandoval Vallarta (1933), and Vallarta (1933, 1935, 1937).
- They predicted that positive charged particles would deviate to the west and negative charged ones to the east. Vallarta convinced Compton to make new measurements to test their predictions. Measurements were made in Mexico by Luis W. Alvarez, student of Compton and through these experiments Compton and Alvarez determined that cosmic radiation consisted mainly of protons.
- In 1934 Sandoval Vallarta formed a group of researchers in cosmic ray physics at the National University of Mexico (UNAM).

Cosmic Ray Physics in Mexico

- 1951 Biermann, Haxel, Shulter pointed out the possibility of detection of solar neutrons at Earth.
- In 1954 UNAM acquired a neutron monitor and from 1954-1958 research was focused on the albedo of cosmic rays using a Solar Neutron Telescope in Sierra Negra.



- In 1955 Prof. Vallarta organized the 4th ICRC held in Guanajuato, Mexico.
- By 1958 the center of physics on cosmic rays moved to the Insitute of Geophysics at UNAM where a new group was organized by Ruth Gall.
- Cosmic ray physics continued in Mexico in the 60's and 70's concentrating on the development of instrumentation leading to joining HEP ……

Experimental Elementary Particle Physics in Mexico

- In 1981 Jorge Flores Director of Centro de Investigacion de Estudios Avanzados del Instituto Politecnico Nacional (CINVESTAV), invited Leon Lederman , Director of Fermilab, to visit Mexico.
- Discussions resulted in January of 1982 a conference at Cocoyoc "The Panamerican Symposium on Physics and Technology of High Energy Physics".
- In addition to the physics presentations there were sessions on the sociology of HEP and the perspectives of HEP in Latin America.
- This meeting directly led to formation of an experimental HEP group at UNAM led by Clicerio Avilez.
- Clicerio Avilez, Matías Moreno and Arnulfo Zepeda decided to convert themselves from theoretical to experimental physicists.
- CINVESTAV initiated a program of student visits to Fermilab with the goal of becoming experimental physicists.
- Clicerio Avilez moved his group to the University of Guanajuato where it is today.

Experimental Elementary Particle Physics in Mexico

- Later in the mid-80's CINVESTAV had three doctoral students working on HEP experiments at Fermilab each working under the supervision of a Fermilab physicist.
- Luis Villaseñor from Morelia who was the first student to get his doctorate in experimental HEP in Mexico (1988) working on UA1 at CERN.
- The first Mexican experimentl HEP doctorate from Fermilab went to Gerardo Moreno (1989) who joined the University of Guanajuato.
- In 1989 there was a census of physicists with a doctorate in Mexico and 29 were in HEP of which three were experimentalists: Clicerio Avilez and G. Moreno from Guanajuato and

- **Currently Mexican universities and institutes have order 45 PhDs and 65 students in HEP.**

Enter Fermilab – Leon Lederman

- The relationship between Fermilab and Latin American HEP physicists was profoundly influenced by Leon.
- In his own words: As Director of Fermilab, starting in 1979, I began a series of meetings with scientists in Latin America. The motivation was to stir collaboration in the field of high energy particle physics, the central focus of Fermilab.
  - In the next 13 years, these Pan American Symposia stirred much discussion of the use of modern physics, created several groups to do collaborative research at Fermilab, and often centralized facilities and, today, still provides the possibility for much more productive North-South collaboration in research and education.
- Strong groups did exist in Brazil, Mexico and Argentina, but progress in the construction of modern scientific instruments lagged. … Nevertheless, to me Latin America represented a huge potential treasure of human resources which would, I was sure, eventually be devoted to scientific research to the benefit of the nations of South and Central America and, indeed, the world.

Latin America – Fermilab Collaboration

- These initial meetings led to a series of Pan American Symposium on Elementary Particles and Technology with the first in Mexico that touched much more than the formation of teams from Brazil, Mexico and Colombia participating in research at the Fermilab.
- Workshops on accelerator technology, on science education, and other topics in scientific research stimulated by the collaboration, were held in Mexico, Brazil, Costa Rica, Bolivia, Honduras, and Peru.
- The connections established by Leon held through years at Fermilab where attention to the area was not as strong as under Leon. Now, under the active interest of both Pier Oddone and Young-Kee Kim, there is renewed interest in a Latin American Initiative. This Initiative was announced in Chile at the end of 2010.
- Pier in particular has been able to visit Latin American universities and agencies and, in their native language, promote the benefits of the Latin American- Fermilab connection.

Latin America-Fermilab Theory Collaboration
15 Students

- Theory Program run by Marcela Carena since 2004, in the Fermilab Theory Department
  - Alejandro Daleo – Argentina Now: Industry in Zurich
  - Julian Candia – Argentina Now: Industry in Computing
  - Roberto Noriega Papaqui - Mexico Now: Asst. Professor in Universidad Autonoma del Estado de Hidalgo, Mexico
  - Alejandro Szynkman – Argentina Now: Asst. Professor in La Plata University
  - Maximiliano Rivera – Chile Now: Asst Professor in Universidad Tecnica Federico Santa Maria, Chile
  - Pablo Barros - Brasil Now: Unknown
  - Juan Racker - Argentina Now: Postdoctoral fellow in Valencia, Spain

Latin America-Fermilab Theory Collaboration

- Boris Panes – Chile Now: Postdoctoral Fellow in DESY
- Jose Francisco Zurita – Argentina Now: Postdoctoral fellow in Univ of Mainz, Germany
- Roger Jose Hernandez Pinto-Mexico Now: Postdoctoral Fellow at University of Buenos Aires, Argentina
- Mauricio Ramirez – Peru Now: PhD Univ. of Valencia, Spain
- Pedro Accioly Nogueira Machado – Brasil Now; Postdoctoral Fellow in Universidad Autonoma de Madrid
- Alfonso Diaz Furlong – Mexico Now; Back Mexico for Ph D
- Maria Pia Zuritia – Argentina Now: Postdoctoral in Spain
- Carlos Arguelles –Peru Now: PhD in Univ of Wisconsin, USA

Latin American Participation in Fermilab Experiments

FIXED TARGET

- E687 Heavy Flavor photo-production
  - Universidad de Puerto Rico-Mayaguez
- FOCUS (E831) successor of E687
  - Centro Brasileiro de Pesquisas Fisicas (CBPF), Brasil 2PhDs
  - Centro de Investigacion de Estudios Avanzados del Instituto Politecnico Nacional (CINVESTAV), Mexico City, Mexico
  - University of Guanajuato, Leon, Guanajuato, Mexico
  - Pontificia Universidade Catolica, Rio de Janeiro, Brazil
  - University of Puerto Rico, Mayaguez
- E690 Light meson spectroscopy
  - Universidad de Guanajuato, Mexico
  - Universidad Michoacana, Morelia, Michoacán, México

Latin American Participation in Fermilab Experiments

- E691 Photoproduction of charmed particles
  - Centro Brasileiro de Pesquisas Fisicas (CBPF), Rio de Janeiro, Brasil
  - Universidad Autonoma de Puebla, Mexico

- E769 Hadroproduction of charm
  - Centro Brasileiro de Pesquisas Fisicas (CBPF), Brasil 7 PhDs

- SELEX (E781) Charmed Baryons
  - Centro Brasileiro de Pesquisas Fisicas (CBPF), Brasil 2PhDs
  - Instituto de Fisica, Univesidad Autonoma de San Luis Potosi, Mexico
  - Universidade Federal da Paraiba, Paraiba, Brasil
  - Universidade de Sao Paulo

Latin American Participation in Fermilab Experiments

- E791 Photo-production and decay of charmed particles
  - Centro Brasileiro de Pesquisas Fisicas (CBPF) Brasil — 4 PhDs, 3 MS
  - CINVESTAV, Mexico City, Mexico
  - Universidad Autonoma de Puebla, Mexico
- KTEV (E799 & E832) – Kaon Physics at the Tevatron
  - Universidade Estadual de Campinas, Brasil — 2 PhDs
  - Universidade de Sao Paulo. Brasil
- Hyper CP (E871) CP violation, Xi and Lambda decays
  - University of Guanajuato, Mexico

Latin American Participation in Fermilab Experiments

COLLIDER

- D0
  - LAFEX, Centro Brasileiro de Pesquisas Fisicas, Brasil 9 PhDs
  - Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brasil
  - Universidad de los Andes, Bogota, Colombia
  - Universidad San Francisco de Quito, Quito, Ecuador
  - CINVESTAV, Mexico City, Mexico

- Latin American groups now involved in LHC experiments (CMS)
  - Puerto Rico
  - Colombia
  - Mexico
  - Brasil

Latin American - Fermilab Collaboration in Experiments

COSMIC FRONTIER

- DES (Dark Energy Survey)
  - Observatorio Nacional de Brasil
  - Universidade Federal do Rio Grande do Sul
  - Centro Brasileiro de Pesquisas Fisicas (CBPF), Rio de Janeiro, Brasil
- AUGER (E681)
  - Argentina – 9 universities or institutes – 15 PhDs
  - Bolivia – 2 universities
  - Brasil – 9 universities or institutes – 19 PhDs
  - Mexico – 5 universities – 12 PhDs
- DAMIC (Dark Matter)
  - Universidad Nacional de Paraguay
  - Instituto Balseiro Argentina
  - Universidad Nacional de Mexico

Latin American Participation in Fermilab Neutrino Experiments – Intensity Frontier

NEUTRINO EXPERIMENTS

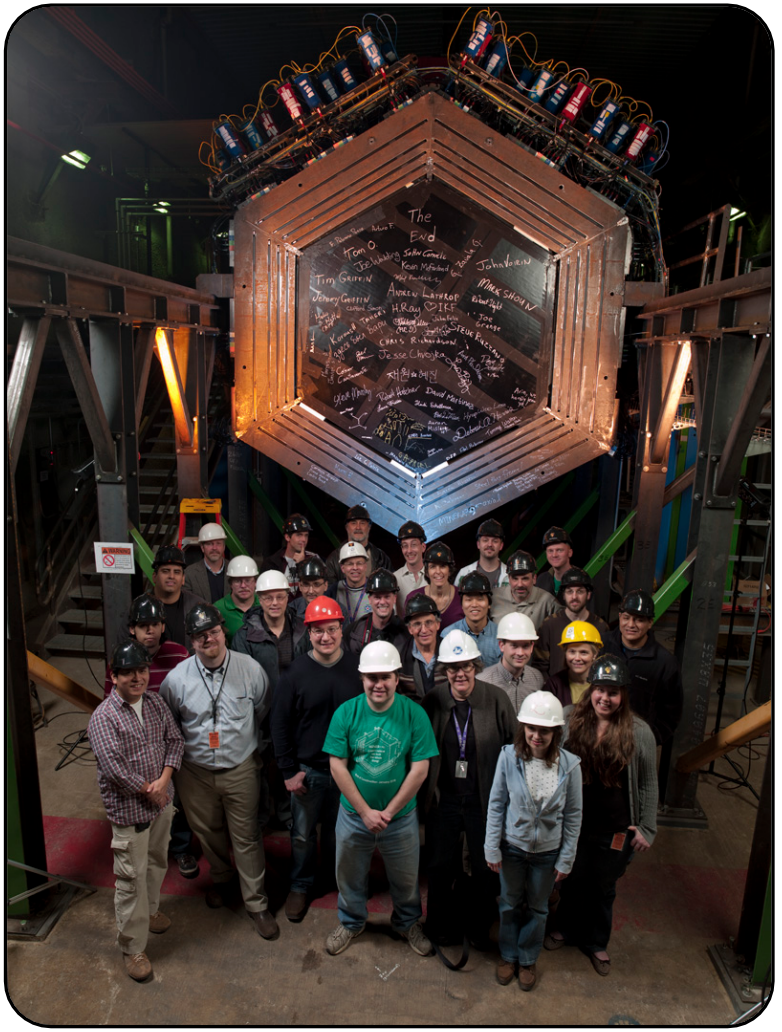
- MINOS / MINOS+
  - Universidade Estadual de Campinas, Brasil — Brasil 1 PhD, 2 MS
  - Universidade de Sao Paulo, Brasil
  - Universidade de Goias, Brasil

- **MINERvA (E938)**
  - Centro Brasileiro de Pesquisas Fisicas (CBPF), Brasil — 1 (+1) PhD
  - Universidad Tecnica Federico Santa Maria, Valparaiso, Chile
  - Universidad de Guanajuato, Mexico — (1 PhD)
  - Pontifica Universidad Catolica de Lima, Peru
  - Universidad Nacional de Ingenieria, Lima, Peru

MINERνA

~80 collaborators from particle and nuclear physics

University of Athens
University of Texas at Austin
Centro Brasileiro de Pesquisas Físicas
Fermilab
University of Florida
Université de Genève
Universidad de Guanajuato
Hampton University
Inst. Nucl. Reas. Moscow
Mass. Col. Lib. Arts
Northwestern University
University of Chicago
Otterbein University
Pontificia Universidad Catolica del Peru
University of Pittsburgh
University of Rochester
Rutgers University
Tufts University
University of California at Irvine
University of Minnesota at Duluth
Universidad Nacional de Ingeniería
Universidad Técnica Federico Santa María
William and Mary



MINERvA Latin American Program
Initiated in late 2005

- CBPF; Prof Helio da Motta - Brasil
  - MS Jose Palomino
  - Doc Jose Palomino
  - MS Arturo Fiorentini
  - Doc Arturo Fiorentini
  - MS David Martinez
  - Pdoc Cesar Castromonte
  - Doc Kenyi Hurtado
  - MS Cesar Sotelo
  - Doc David Martinez
  - Pdoc Thiago Muhlbeier
- PUCP; Prof Alberto Gago – Peru
  - MS Leo Aliaga
  - Doc Leo Aliaga (W&M)
  - Doc Jose (Pepe) Bazo
  - MS Carlos Perez
  - MS Carmen Araujo
  - MS Noemi Ochoa
  - MS J.P. Velasquez
  - MS Gonzalo Diaz
  - Doc Carmen Araujo
  - MS Maria Jose Bustamente
- UNI; Prof Javier Solano – Peru
  - MS Marcos Alania
  - MS Carlos Romero
  - MS Adolfo Chamorro
  - MS Kenyi Hurtado
  - MS Ivan Yupanqui

MINERvA Latin American Program

- Guanajuato, Mexico; Prof Julian Felix, Prof Gerardo Guzman, Prof Victor Castillo (U Guadalajara) and Prof Zaida Urrutia (Guatemala)
  - MS Jorge Castorena
  - MS Aaron Higuera
  - Doc Aaron Higuera
  - Eng Alfonso Balcazar
  - Eng Julio Capetillo
  - MS Zaidy Urrutia
  - Doc Zaidy Urrutia
  - Doc Ranferi Gutierrez
  - MS Edgar Valencia
  - Doc Edgar Valencia
  - MS Guadalupe Barrios (Guatemala)
- US, Chile; Prof Will Brooks, Prof Jon Miller
  - MS Cristian Peña
  - MS Giuliano Maggi

9 Professors: 32 trips to Fermilab for 1.5 to 6 week.

1 (2) Sabbaticals

23 Masters students

11 Doctoral students

3 PostDocs

2 International Fellow students

MINERνA ν Scattering Physics Program

In red → currently studied * → Latin American Participation

- *Quasi-elastic Brazil, Mexico (Guatemala)
- Resonance Production - 1pi
- *Resonance/transition Region - npi resonance to DIS - Brazil, Peru
- *Inclusive and Deep-Inelastic Scattering - Brazil, Peru
- *Coherent Pion Production Mexico
- Strange and Charm Particle Production
- *σ_T , Structure Functions and PDFs Brazil
  - High-x parton distribution functions
- *Nuclear Effects (He, C, H_2O, Fe and Pb) Brazil, Peru
- *Generalized Parton Distributions Chile

- *Test Beam Effort – designed by PUCP, Peru student, built and commissioned by Peru and Brazil students.

First MINERvA PRLs

Measurement of Muon Neutrino Quasi-Elastic Scattering on a Hydrocarbon Target at E ν ~ 3.5 GeV

G. A. Fiorentini,1 D. W. Schmitz,2, 3 P. A. Rodrigues,4 L. Aliaga,5, 6 O. Altinok,7 A. Bodek,4 D. Boehnlein,3 R. Bradford,4 W.K. Brooks,8 H. Budd,4 A. Butkevich,9 D.A.M. Caicedo,1 C.M. Castromonte,1 M.E. Christy,10 J. Chvojka,4 H. da Motta,1 D.S. Damiani,5 I. Danko,11 M. Datta,10 M. Day,4 R. DeMaat,3, * J. Devan,5 G.A. D ´ıaz,6 S.A. Dytman,11 B. Eberly,11 D.A. Edmondson,5 J. Felix,12 L. Fields,13 T. Fitzpatrick,3, * A.M. Gago,6 H. Gallagher,7 B. Gobbi,13, * R. Gran,14 D.A. Harris,3 A. Higuera,12 I.J. Howley,5 K. Hurtado,1, 15 M. Jerkins,16 T. Kafka,7 M.O. Kanter,5 C. Keppel,10 M. Kordosky,5 A.H. Krajeski,5 S.A. Kulagin,9 T. Le,17 A.G. Leister,5 G. Maggi,8, † E. Maher,18 S. Manly,4 W.A. Mann,7 C.M. Marshall,4 K.S. McFarland,4, 3 C.L. McGivern,11 A.M. McGowan,4 A. Mislivec,4 J.G. Morf ´ın,3 J. Mousseau,19 D. Naples,11 J.K. Nelson,5 G. Niculescu,20 I. Niculescu,20 N. Ochoa,6 C.D. O'Connor,5 J. Osta,3 J.L. Palomino,1 V. Paolone,11 J. Park,4 C.E. Patrick,13 G.N. Perdue,4 C. Pen ˜a,8 L. Rakotondravohitra,3 R. D. Ransome,17 H. Ray,19 L. Ren,11 K.E. Sassin,5 H. Schellman,13 R.M. Schneider,5 E.C. Schulte,17, ‡ P. Sedita,4 C. Simon,21 F.D. Snider,3 M.C. Snyder,5 J.T. Sobczyk,22, 3 C.J. Solano Salinas,15 N. Tagg,23 W. Tan,10 B.G. Tice,17 G. Tzanakos,24, * J.P. Vel ´asquez,6 J. Walding,5, § T. Walton,10 J. Wolcott,4 B.A. Wolthuis,5 G. Zavala,12 D. Zhang,5 and B.P.Ziemer21

(The MINERvA Collaboration)

1Centro Brasileiro de Pesquisas F ´ısicas, Rua Dr. Xavier Sigaud 150, Urca, Rio de Janeiro, RJ, 22290-180, Brazil

2Enrico Fermi Institute, University of Chicago, Chicago, IL 60637 USA

3Fermi National Accelerator Laboratory, Batavia, Illinois 60510, USA

Latin American - Fermilab Smaller Scale United Efforts – Latin American Initiative

- CONNIE – Reactor experiment in Brasil for coherent scattering with important input from Fermilab (Juan Estrada).
- Juan Estrada with Jeronimo Blostein from Bariloche, Argentina invented a high resolution neutron imager and built a prototype at FNAL. The DOE submitted a patent application for this technology with co-inventors in Fermilab and Argentina.
- Fermilab International Fellows
  - Michelle de Madeiros Univ. Federal de Goias, Brazil Student MINOS
  - Carlos Escobar Campinas, Brazil Scientist LBNE
  - David Martinez CBPF, Brazil Student MINERvA
  - Guillermo Moroni Univ. Nac. Sur, Argentina Student Astro
- Fermilab sponsored 2012 CTEQ QCD School in Lima, Peru
  - 40 Latin American university students

Conclusions

- **Since the late 70's Fermilab has played a proactive role in encouraging Latin American participation in the Theory and Experimental life at the lab.**
- **Already a strong Latin American – Argentina, Brasil, Chile, Colombia, Mexico & Peru – presence in Fermilab Experiments.**
- **Need to schedule more Workshops and Schools in Latin America like the 2012 CTEQ QCD School in Peru and the 2012 NuInt Workshop in Rio de Janeiro.**
- **There are several working models (MINERvA) of how to encourage Latin American physicists collaborating at Fermilab.**
- **Important next step in the Latin American Initiative is formalized agreements between Fermilab and collaborating institutions that can then be taken to national research and funding agencies.**

Acknowledgements

- Will Brooks
- Marcela Carena
- Carlos Escobar
- Juan Estrada
- Julian Felix
- Gaston Gutierrez
- Burce Hoeneisen
- Carlos Hojvat
- Jacobo Konigsberg
- Helio da Motta
- Juan Pablo Negret
- Roy Rubinstein
- Arnulfo Zepeda

The MINERνA Model: Latin American collaboration at FNAL

- Students studying for their Masters Degree 23 students
  - Visiting Scientist Invitation
  - J-1 visa Trainee Program: On-site Mentor
  - 1-year residency at Fermilab working on experiment
  - As long as funding permits: Fermilab covers housing costs and adds to perDiem
- Students studying for their Doctorate 11 students
  - Visiting Scientist Invitation and Scholar Visa
  - Multi-year residency at Fermilab working on experiment
  - As long as funding permits: Fermilab covers housing costs
- Post Doctoral Associates 3
  - Visiting Scientist and scholar visa
  - Multi-year residency at Fermilab working on experiment
  - As long as funding permits: Fermilab covers housing costs
- Professors
  - Multiple 2-6 week visits and one 1-year Sabbatical 32visits 1 Sabbatical
  - As long as funding permits: Fermilab covers housing costs

Brasil (and Mt. Chacaltaya - Bolivia)

- Lattes continued his own research in particle physics at Chacaltaya peak in Bolivia, using nuclear emulsions to record and analyze the tracks of cosmic particles.
- Laboratório de Física Cósmica, Mt. Chacaltaya, Bolívia,5200 masl, created in 1949.