



CERN-CONACyT BEAM programme for doctoral and technical students

Frank Zimmermann, CERN, BE Department

Visit of Dr. Enrique Cabrero Mendoza, Director-General, CONACyT

23 March 2017

many thanks to: Guillermo Contreras, Gerardo Herrera, Idefonso Leon-Monzon, Ricardo Lopez, Mauro Napsuciale, Humberto Maury Cuna, Jose Salicio, Richard Scrivens, Bruce Yee, Alan Valdivia, + all the excellent Mexican students & colleagues

references:

- (1) M. Napsuciale, J.G. Contreras, "Creation of a group on particle accelerator science and technology in Mexico," 25 August 2016, <https://arxiv.org/abs/1608.07456>
- (2) J.G. Contreras, "Some comments on accelerator science and technology in Mexico and in the Czech Republic," EuCARD-2 workshop "Universities meet Laboratories", LAL Orsay, 3 November 2016, <https://indico.gsi.de/conferenceDisplay.py?confId=4675>
- (3) H. Maury Cuna, slides on CMAP and CMAP projects

some history

Mexico has a strong HEP community;

up to the 1990's all work in theory & phenomenology

2006 CONACyT call for “Proposal of ideas for the realisation of large scale projects on science or technology”

a group of HEP leaders, led by Gerardo Herrera, and including Mauro Napsuciale and Guillermo Contreras, proposed the development of the science and technology of particle accelerators with the long term goal of constructing a light source in Mexico



CONACyT panel and RedFAE network

Director for Scientific Development of Conacyt, J. L. de la Peña, created an ad-hoc committee to advise him on the feasibility of large scale accelerator projects in Mexico

proposals to focus on light sources and hadron therapy

panel stressed the need of a strong investment in the training of highly qualified human resources

from the outcome of this committee and from the input he got from the RedFAE (CONACyT nat'l network on high-energy physics), **Dr. de la Peña agreed to look for ways to fund prospective students in this area**



first Mexican accelerator student at CERN

Humberto Maury Cuna

M. Sc. (2009) and Ph. D. (2013) under the direction of Frank Zimmermann working on electron cloud effects at the LHC

Funding sources:

EuCARD, HELEN, E-Planet from Europe

CONACyT, RedFAE, CINVESTAV from Mexico





journal articles

PHYSICAL REVIEW SPECIAL TOPICS - ACCELERATORS AND BEAMS 15, 051001 (2012)

Simulations of electron-cloud heat load for the cold arcs of the CERN Large Hadron Collider and its high-luminosity upgrade scenarios

Humberto Maury Cuna and Jesús Guillermo Contreras

Departamento de Física Aplicada, Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional, Unidad Mérida, A.P. 73 Cordemex, 97310 Mérida, Yucatán, México

Frank Zimmermann

CERN, BE Department, 1211 Geneva 23, Switzerland

PHYSICAL REVIEW SPECIAL TOPICS - ACCELERATORS AND BEAMS 16, 011003 (2013)



First electron-cloud studies at the Large Hadron Collider

O. Domínguez,* K. Li,† G. Arduini, E. Métral, G. Rumolo, and F. Zimmermann

CERN, Geneva, Switzerland

H. Maury Cuna

Departamento de Física Aplicada, CINVESTAV, Unidad Mérida, A.P.73 Cordemex, 97310, Mérida, Yucatán, México



the BEAM programme

since 1998 there is a cooperation agreement between CONACyT and CERN

BEAM, an addendum to this agreement, was written to formalise the accelerator collaboration between Mexico and CERN

The BEAM programme aims at the transfer of knowledge for the development of particle accelerators between **CERN's** Beams Department and Mexican Institutions, through visits and training in areas of common interest.

the formalities took a long time; finally on January 9, 2015 it was officially signed, but it was de facto operating before that date

BEAM has helped in creating an official environment to ask for funding and several students have benefitted from this

ADDENDUM 1: THE BEAM PROGRAMME

Following Article 3.2 of Protocol P111 between the European Organization for Nuclear Research (**CERN**) and The National Council of Science and Technology (**CONACYT**), the parties celebrate this Addendum to define the collaboration between them in the BEAM programme at **CERN**.

The BEAM programme aims at the transfer of knowledge for the development of particle accelerators between **CERN's** Beams Department and Mexican Institutions, through visits and training in areas of common interest.

The BEAM programme includes the training of Mexican students enrolled at universities or other high-level educational Institutions in Mexico. Students who are following master or doctorate studies and who are in possession of a standard **CONACYT** grant (2014 amount in US: approximately US \$900) are eligible for application for participation in the BEAM programme.

CERN shall provide adequate facilities, equipment, materials and supervision for the training of the Mexican students.

CONACYT shall provide adequate financial resources for these students to cover

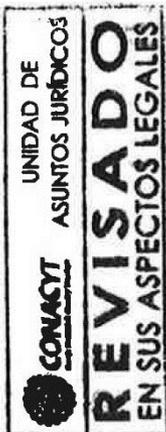
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DONE IN MEXICO CITY, ON JANUARY 9th, 2015, IN 4 (FOUR) COPIES, 2 (TWO) IN THE ENGLISH LANGUAGE AND 2 (TWO) IN THE SPANISH LANGUAGE.

FOR THE EUROPEAN ORGANIZATION
FOR NUCLEAR RESEARCH

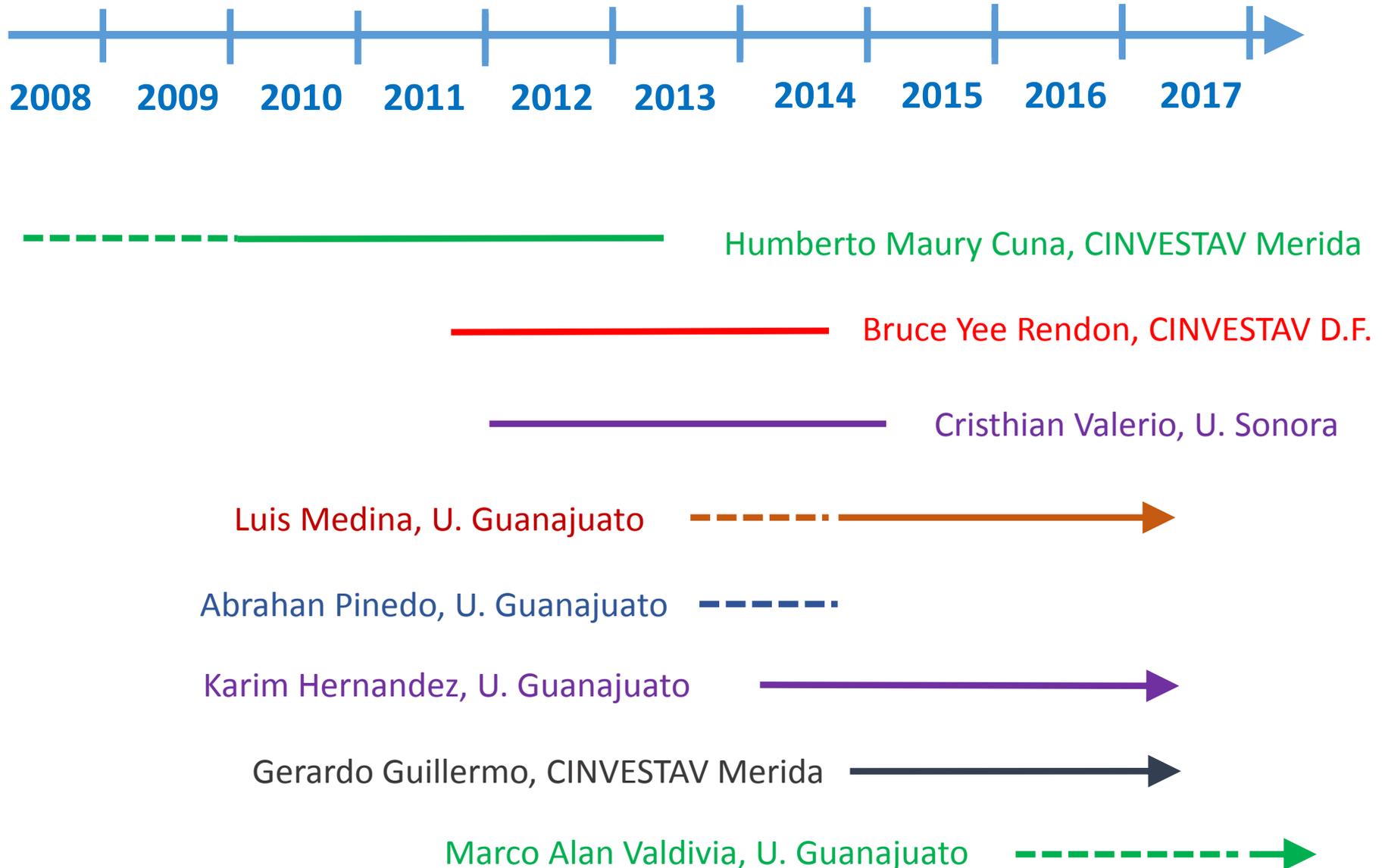
FOR THE NATIONAL COUNCIL OF
SCIENCE AND TECHNOLOGY




SERGIO BERTOLUCCI
Director for Research and
Scientific Computing


JULIA TAGÜENA PARGA
Deputy Director General
for Scientific Development

Mexican accelerator students at CERN



**Simulations of fast crab cavity failures in the high luminosity
Large Hadron Collider**

Bruce Yee-Rendon^{*,†} and Ricardo Lopez-Fernandez

Departamento de Física, Centro de Investigación y de Estudios Avanzados del I.P.N.,

PHYSICAL REVIEW SPECIAL TOPICS—ACCELERATORS AND BEAMS **18**, 080101 (2015)

Negative ion beam space charge compensation by residual gas

Cristhian A. Valerio-Lizarraga^{*}

PHYSICAL REVIEW ACCELERATORS AND BEAMS **20**, 012001 (2017)

Design and testing of a four rod crab cavity for High Luminosity LHC

B. Hall,[†] G. Burt, R. Apsimon,^{*} C. J. Lingwood, and A. Tutte

*Engineering Department, Lancaster University, Lancaster LA1 4YW, United Kingdom
and Cockcroft Institute, Daresbury Laboratory, Warrington WA4 4AD, United Kingdom*

A. Grudiev, A. Macpherson, M. Navarro-Tapia, and R. Calaga

CERN, Geneva CH-1211, Switzerland

K. G. Hernández-Chahín

DCI-UG, Guanajuato 37150, Mexico

R. B. Appleby

Mexican students contribute to key projects

Large Hadron Collider (LHC)

electron cloud (H. Maury Cuna, CINVESTAV Merida)

synchrotron radiation (G. Guillermo, CINVESTAV Merida)

LHC Injector Upgrade (LIU)

Linac4 (C. Valerio, U. Sonora)

High-Luminosity LHC (HL-LHC)

crab-cavity beam dynamics (B. Yee Rendon, CINVESTAV D.F.)

RF crab cavity development (Karim Hernandez, U. Guanajuato)

CLIC

ion instabilities (A. Pinedo, U. Guanajuato)

Future Circular Collider (FCC)

FCC-hh and FCC-ee optics design (L. Medina, U. Guanajuato)

FCC-ee beamstrahlung and monochromatization for direct Higgs production
(M. Valdivia, U. Guanajuato)

CERN – Mexico accelerator collaboration

the present situation

three students have got their Ph. D. from Mexican institutions for their work at CERN

- ✓ Humberto Maury (now professor at U. Guanajuato)
- ✓ Cristhian Valerio (now professor at U. Sinaloa)
- ✓ Bruce Yee (now postdoc at KEK/J-PARC, Japan)

currently
training
students
and starting
groups in
Mexico

five Mexicans are currently working on accelerator topics at CERN

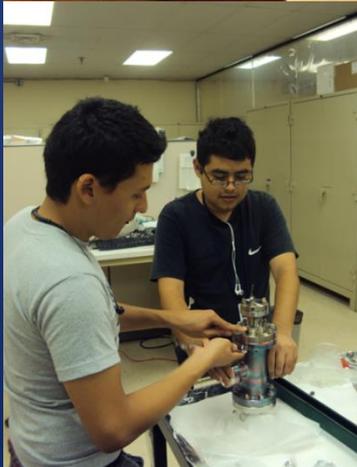
- ✓ Alejandro Castilla (CERN fellow)
- ✓ Gerardo Guillermo (Ph. D. student)
- ✓ Karim Hernandez (Ph. D. student)
- ✓ Luis Medina (Ph. D. student)
- ✓ Alan Valdivia (now Ph.D. student, coming back to CERN soon)

The background of the slide features a blue-tinted image of a particle accelerator's internal structure, showing various cylindrical and metallic components. The overall aesthetic is technical and scientific, with a focus on the machinery of the accelerator.

**Mexican Particle Accelerator
Community**

**Comunidad Mexicana de
Aceleradores de Partículas
(CMAP)**

Founding Members of the CMAP



#AcceleratorTEAM*

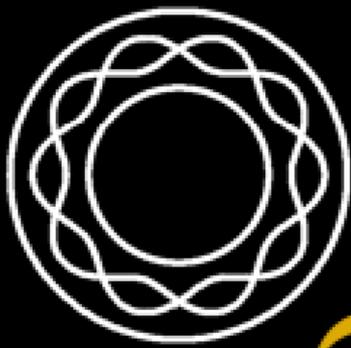


*Dr. Valerio's and Dr. Maury's students
(CMAP's new generation)

MePAS 1 (2011)



MePAS 2 (2015)



MEPAS 3

- November 2017
- 30 students (15 engineers and 15 physicists)
- 1 week: Theory morning sessions, lab afternoon sessions, night tutorial and homework sessions
- Program and organization ready
- Facebook: CMAPmex



BIENVENIDOS

MePAS

Mexican Particle Accelerator School
September 26-October 1, 2011
Guanajuato, Guanajuato, Mexico





CERN experts visiting Mexico

MePAS1 Guanajuato – 2011 - Albert Hofmann & Frank Zimmermann

Humberto Maury PhD defence Merida – 2013 – Frank Zimmermann

Bruce Yee PhD defence Mexico D.F. – 2014 – Frank Zimmermann

BCVSPIN-MSPF-Mitchell Manzanillo – 2014 - Frank Zimmermann

MePAS2 Guanajuato – 2015 - Richard Scrivens

*CERN Latin-American School of High Energy Physics Querétaro –
2017 – Michelangelo Mangano, Martijn Mulders*





COMAP Projects:

“Design and construction of a mini-linac for educations purposes”

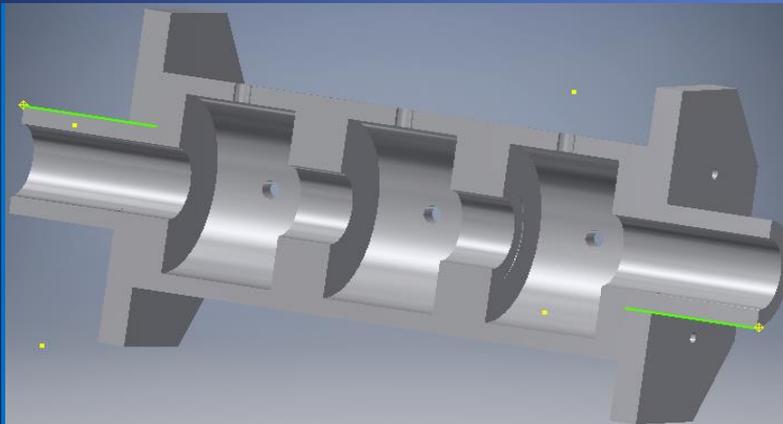
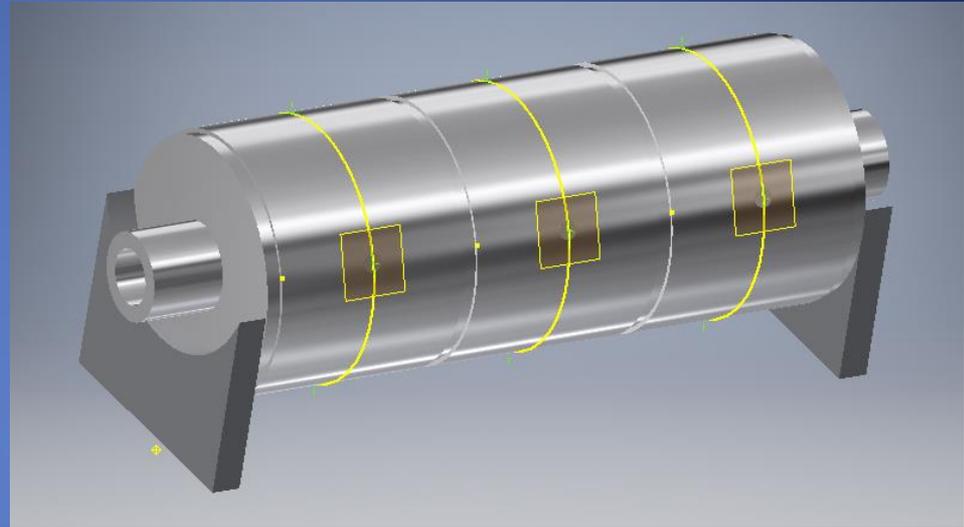


Everardo Granados
Physical engineer
(UG)

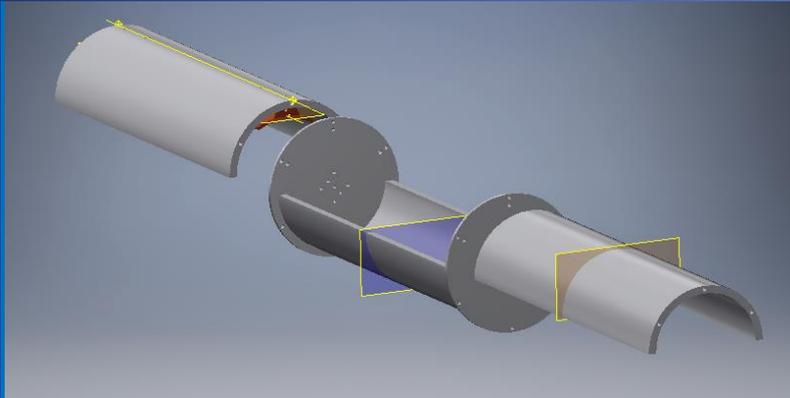


Veronica Bravo
Mechanical Engineer
(ITH)

**Mini-linac to be used at
MePAS3 for lab sessions**



“Design and construction of a stripline beam kicker”



Stripline beam kicker (BPM) to be used at MePAS3 for lab sessions



Veronica Bravo (Mechanical engineer) – *Design* –
Isaac López Jurado Ing. Mechatronical engineer) –
Construction -

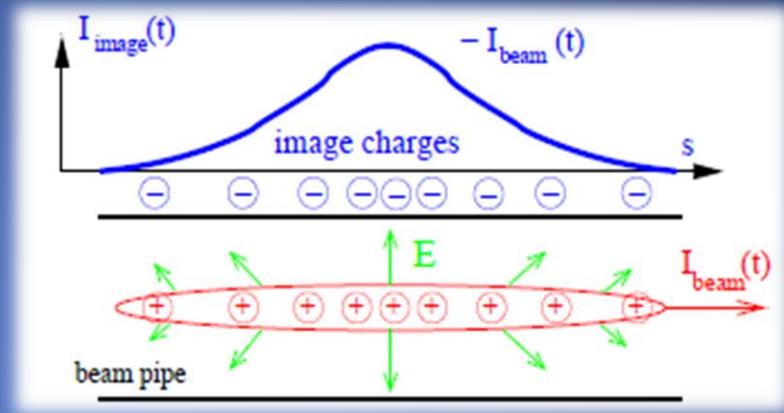


“Design and construction of a Beam Position Monitor”



Fermín Pérez Suárez (Mechatrical engineer) UG – *Master student*

- Device for measuring horizontal and vertical beam position.
- **Beam orbit corrections.**



“Design of an electron gun”

Design of an electron gun for accelerators –
UAS – Beam dynamics simulations



Ricardo Gaspar (Physicist)
UAS – *Master student*

CERN donates RF ion source to UA Sinaloa

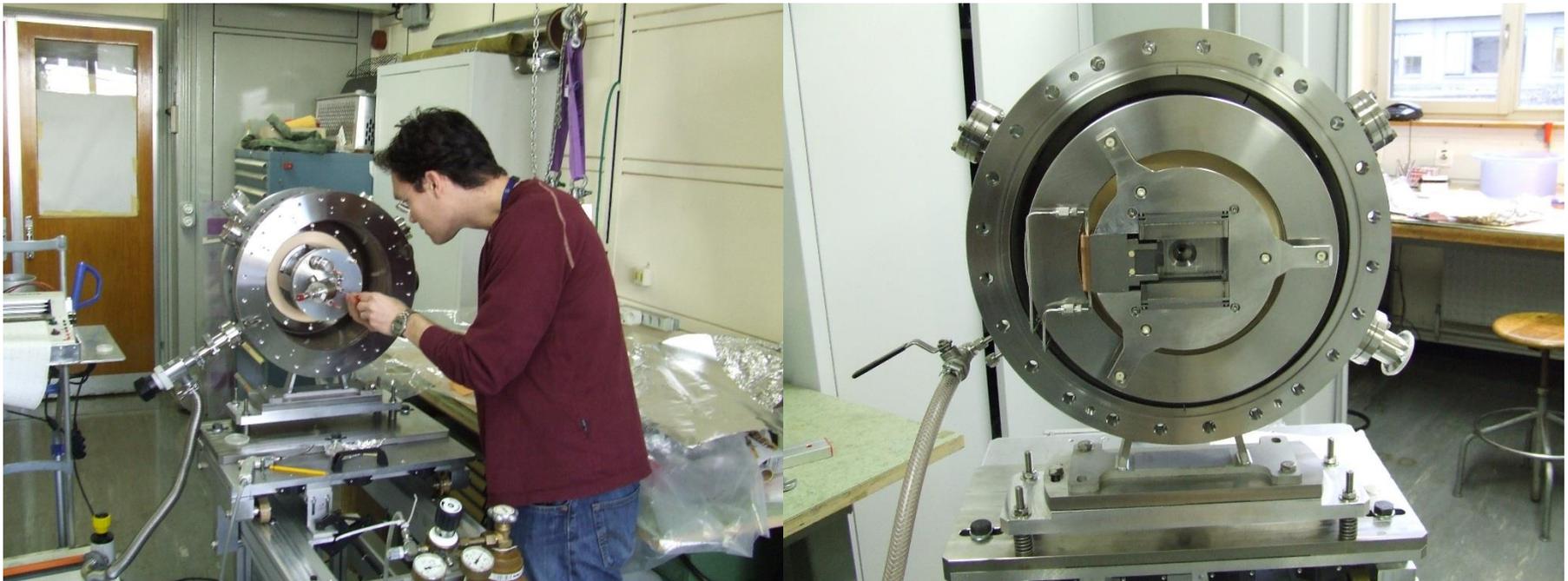
Linac4 H⁻ source prototype built by CERN-DESY collaboration, put into service in 2008; no longer used at CERN now

ion components shipped to Mexico (estimated value 250 kCHF)

(1) ceramic plasma chamber, (2) magnetic circuits, (3) RF antenna, (4) injection flanges with ignition gap, (5) ceramic isolation disks, and (6) front-end chamber

Ion Source applications at the Universidad Autonoma de Sinaloa:

boosting the training of students in producing charged particle beams, electronics for beam instrumentation and detector construction

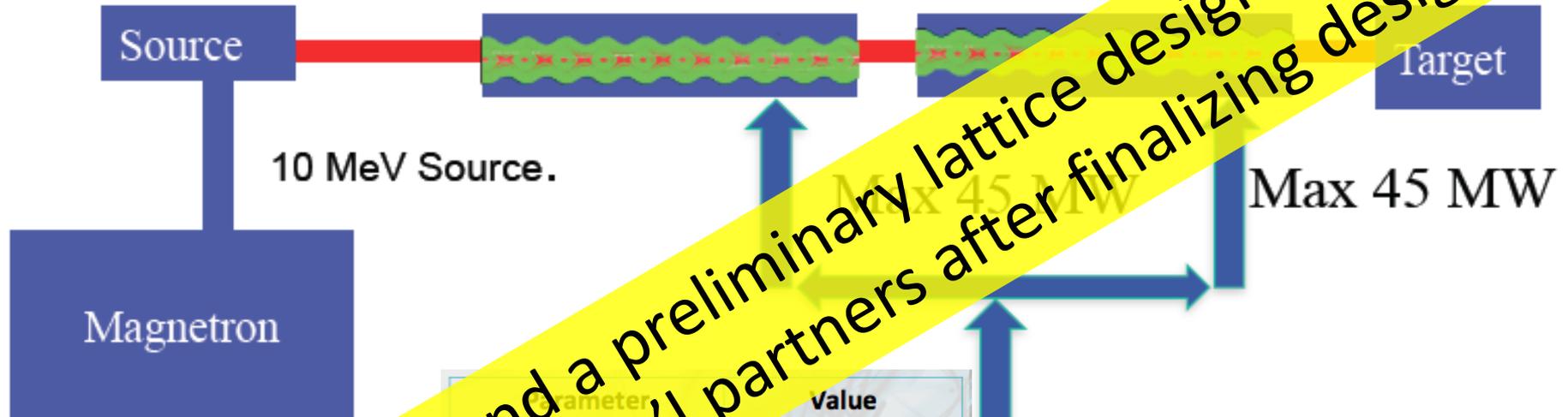


Mexican Linear Accelerator - 100 MeV

(CMAP's Flagship Project)

Pulse Length Max 4 us

Max acceleration 60 MeV per cavity



10 MeV Source.

Max 45 MW

- Electron source.
- S-band.
- Repetition Rate 100 kHz
- Energy Gain in first cavity 10 MeV.
- Magnetron or klystron?
- Other cavities energy given up to 60 MeV.
- Diagnostic created in Mexico

| Parameter | Value |
|------------------------|-----------|
| Beam Energy | 100 MeV |
| Beam transversal size | 2 mm |
| Beam emittance | 1 mm.mrad |
| Source energy | 10 MeV |
| Beam current | 15 mA |
| Energy after Cavity 1 | 55 MeV |
| Energy after Cavity 2 | 100 MeV |
| Number of FODO cells | 3 |
| Phase advance per cell | 60° |

SLED, Max 90 MW

Klystron
50 MW



review of CMAP members and first preliminary design of the proposed CMAP LINAC (100 MeV)

Science and Technology of Accelerators

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²Universidad de Guanajuato,

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⁵Old Dominion University.

⁶The High Energy Accelerator Research Organization.

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Abstract. The Mexican Particle Accelerator Community (CMAP) was created in 2015 and currently its members participate in different experiments around the world. Using their expertise, they are working in develop the particle accelerators area in Mexico. This paper provides a resume of the research done by its members and presents the preliminary design of an electron linear particle accelerator (eLINAC). This proposal will be the first accelerator designed and created in Mexico.



**LINAC – UG:
University of Guanajuato
Accelerator Group Project**

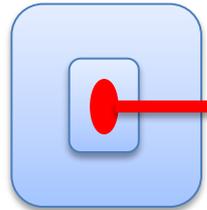


UNIVERSIDAD DE GUANAJUATO

Universidad de Guanajuato:

“Linear Accelerator (LINAC) of 5 MeV”

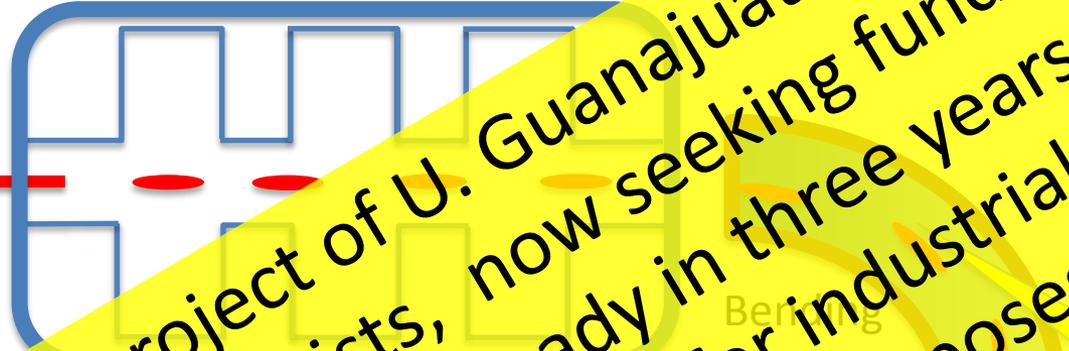
Accelerating structure (RFC+Magnets)
Energy gain = 5 MeV



Source

E = 18 KeV

I = 30 mA



Synchrotron light (THz)



Target

Additional components: power source, vacuum systems, beam diagnostics and instrumentation.

official project of U. Guanajuato,
machine building exists, now seeking funding,
UG LINAC should be ready in three years
as a small accelerator facility for industrial use,
research, and HR training purposes

Photon beam: scientific applications, spectroscopies, radiations, medical materials, detectors calibration, semiconductor treatment, etc.



Target

BEAM programme – scope & impact

BEAM programme and CERN-CONACyT collaboration on accelerator science were **born around 2009; till now nine accelerator students trained at CERN**; Mexican Particle Accelerator Community (CMAP) created in 2015

BEAM students come from many Mexican institutions:

CINVESTAV (Mexico City and Merida campus), U. Sonora, U. Guanajuato ... **recently U. Yucatán started to collaborate on the FCC**

Two major accelerator groups in Mexico – at Guanajuato and Sinaloa – were founded by former BEAM students!

These groups and CMAP are now constructing accelerator components and preparing two accelerator projects: 5 MeV Linac at UG and a CMAP LINAC of 100 MeV

results of the BEAM programme

- training of technical & doctoral students at CERN
- scientific papers and proceedings
- prototypes of accelerator components
- first Mexican accelerator designs
- two strong Mexican accelerator groups
- continuing collaboration between Mexico and CERN (Mexican fellows at CERN; ion source donation etc.)

gracias!

