THE NEED OF A PROTON THERAPY CENTER IN MEXICO

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Outline

- Cancer incidence, epidemiological data
  - (Worldwide and México)
- Types of cancer
- Clinical Linear Accelerators
- State of the art of Radiotherapy in Mexico
- Center of Excellence for Nuclear Medical Physics
- Radionuclide production for nuclear medicine
- Proton Therapy

INTERNATIONAL FRAMEWORK CANCER CASES 2000 - 2020

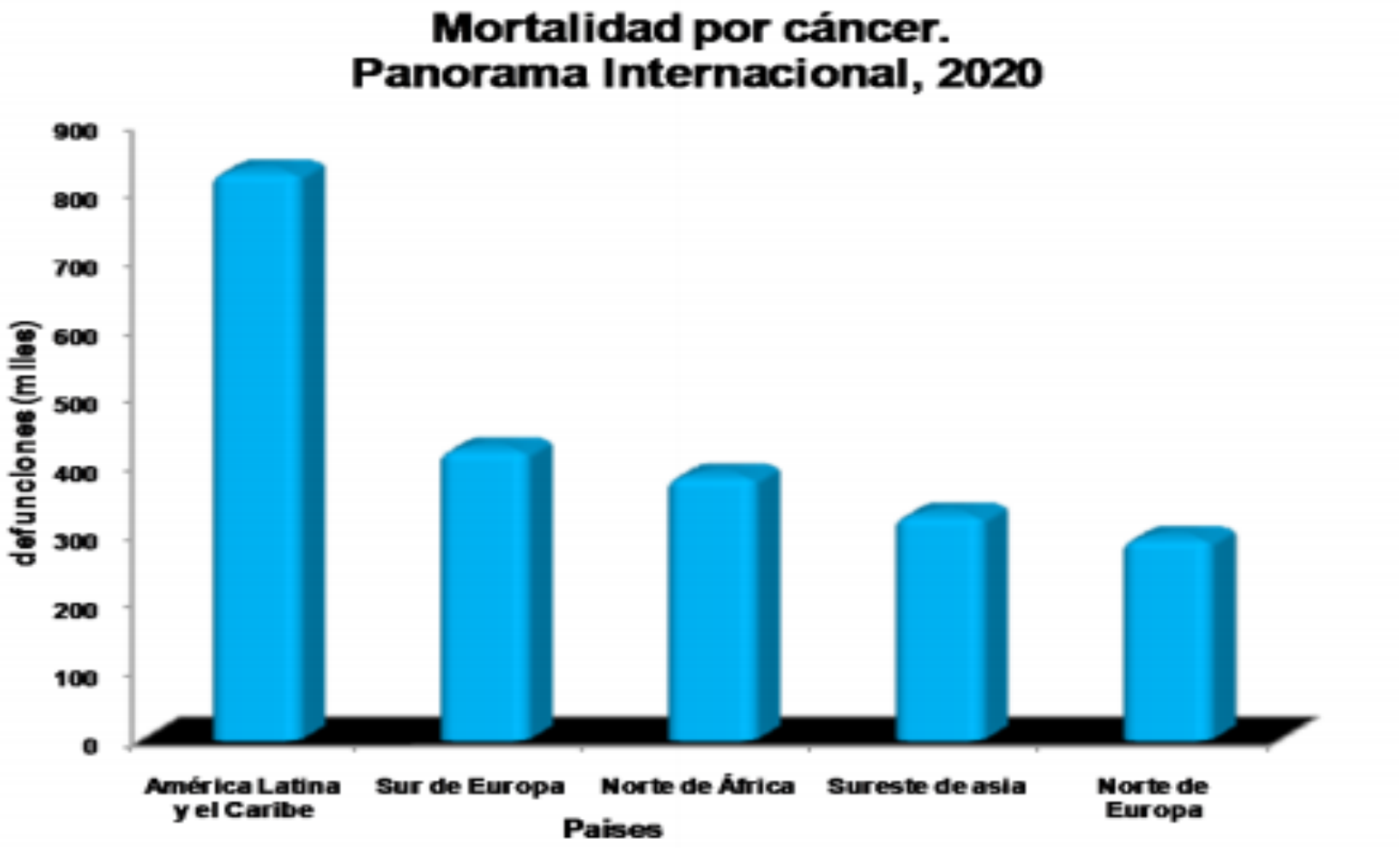
Casos de cáncer Panorama Internacional 2000 - 2020*

Tipos de cáncer	2000		2020	
	Núm.	%	Núm.	%
Pulmón	1,000,200	12.34	2,000,000	13.33
Mama	1,000,100	12.34	2,000,000	13.33
Colon	940,000	11.60	1,700,000	11.34
Estómago	870,000	10.74	1,400,000	9.33
Hígado	560,000	6.91	1,000,000	6.67
Cuello uterino	470,000	5.80	800,000	5.33
Esófago	410,000	5.06	800,000	5.33
Cabeza y cuello	390,000	4.81	700,000	4.67
Vejiga	330,000	4.07	600,000	4.00
Hodgkin	290,000	3.58	550,000	3.67
Leucemia	250,000	3.09	500,000	3.33
Próstata y de testículos	250,000	3.09	500,000	3.33
Páncreas	216,000	2.67	400,000	2.67
Ovario	190,000	2.35	380,000	2.53
Riñón	190,000	2.35	390,000	2.60
Endometrio	188,000	2.32	300,000	2.00
Sistema nervioso	175,000	2.16	250,000	1.67
Melanoma	133,000	1.64	250,000	1.67
Tiroides	123,000	1.52	230,000	1.53
Faringe	65,000	0.80	100,000	0.67
Enfermedad de Hodgkin	62,000	0.77	150,000	1.00
Total Mundial	**8,102,300**	**100.0**	**15,000,000**	**100.00**

Fuente: Informe de Cáncer Organización Mundial de Salud.

* Estimación, Organización Mundial de Salud.

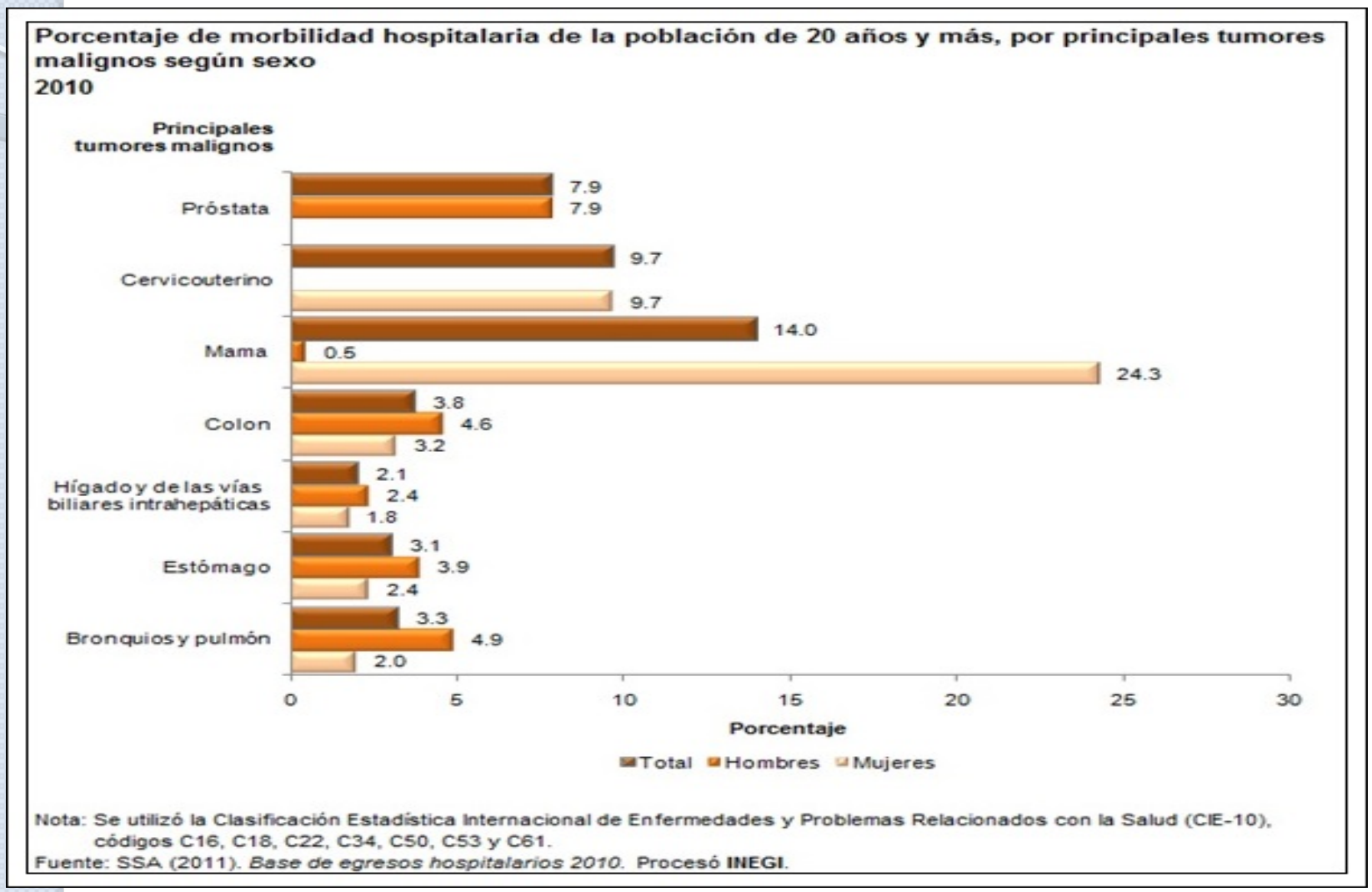
CANCER MORTALITY INTERNATIONAL PROJECTION 2020



Mexico´s Top Ten Mortality Causes

1940	1970	1980	1990	2000	2008
1 Diarrhea and enteritis	Peumonia and influenza	Accidents	Heart diseases	Heart diseases	Heart diseases
2 Peumonia and influenza	Diarrhea and enteritis	Intestinal infectuos diseases	**Malignant Tumor**	**Malignant Tumor**	Mellitus diabetes
3 Malaria	Accidents and violence	Peumonia and influenza	Accidents	Mellitus diabetes	**Malignant Tumor**
4 Measles	Heart diseases	Heart diseases	Mellitus diabetes	Accidents	Accidents
5 Homicides	Perinatal diseases	**Malignant Tumor**	Perinatal diseases	Liver diseases	Liver diseases
6 Bronchitis	**Malignant Tumor**	Cerebrovascular diseases	Peumonia and influenza	Cerebrovascular diseases	Cerebrovascular diseases
7 Liver diseases	Cerebrovascular diseases	Cirrhosis and liver diseases	Intestinal infectuos diseases	Perinatal diseases	EPOC
8 Congenital diseases	Measles	Mellitus diabetes	Cerebrovascular diseases	Peumonia and influenza	Perinatal diseases
9 Heart diseases	Cirrhosis	Homicides and violence	Cirrhosis and liver diseases	EPOC	Homicides
10 Tuberculosis	Tuberculosis	Bronchitis asthma enphysema	Homicides and violence	Homicides	Peumonia and influenza

Main Malignancies In Adults According To Gender



Cases Of Cancer In Children Under 20 Years According To The Histological Type

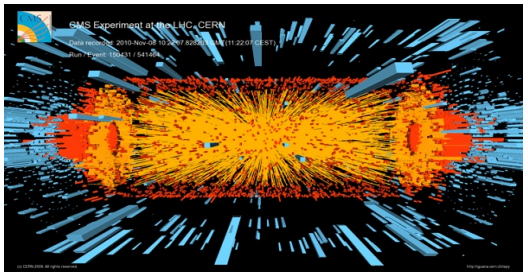
Histologic Type	Cases	%
I. Leukemia	691	30.0
II. Lymphomas and reticuloendothelial neoplasms	394	17.1
III. Brain tumors	274	11.9
IV. Tumors of the sympathetic nervous system	79	3.4
V. Retinoblastoma	93	4.0
VI. Kidney tumors	137	5.9
VII. Liver tumors	40	1.7
VIII. Bone tumors	189	8.2
IX. Soft tissue sarcomas	158	6.9
X. Germ Cell Tumors	161	7.0
XI. Carcinomas and other epithelial neoplasias	26	1.1
XII. Unspecific neoplasms	61	2.6
Subtotal	**2,303**	**100.0**
S/D	1,266	35.5
Total	**3,569**	**100.0**

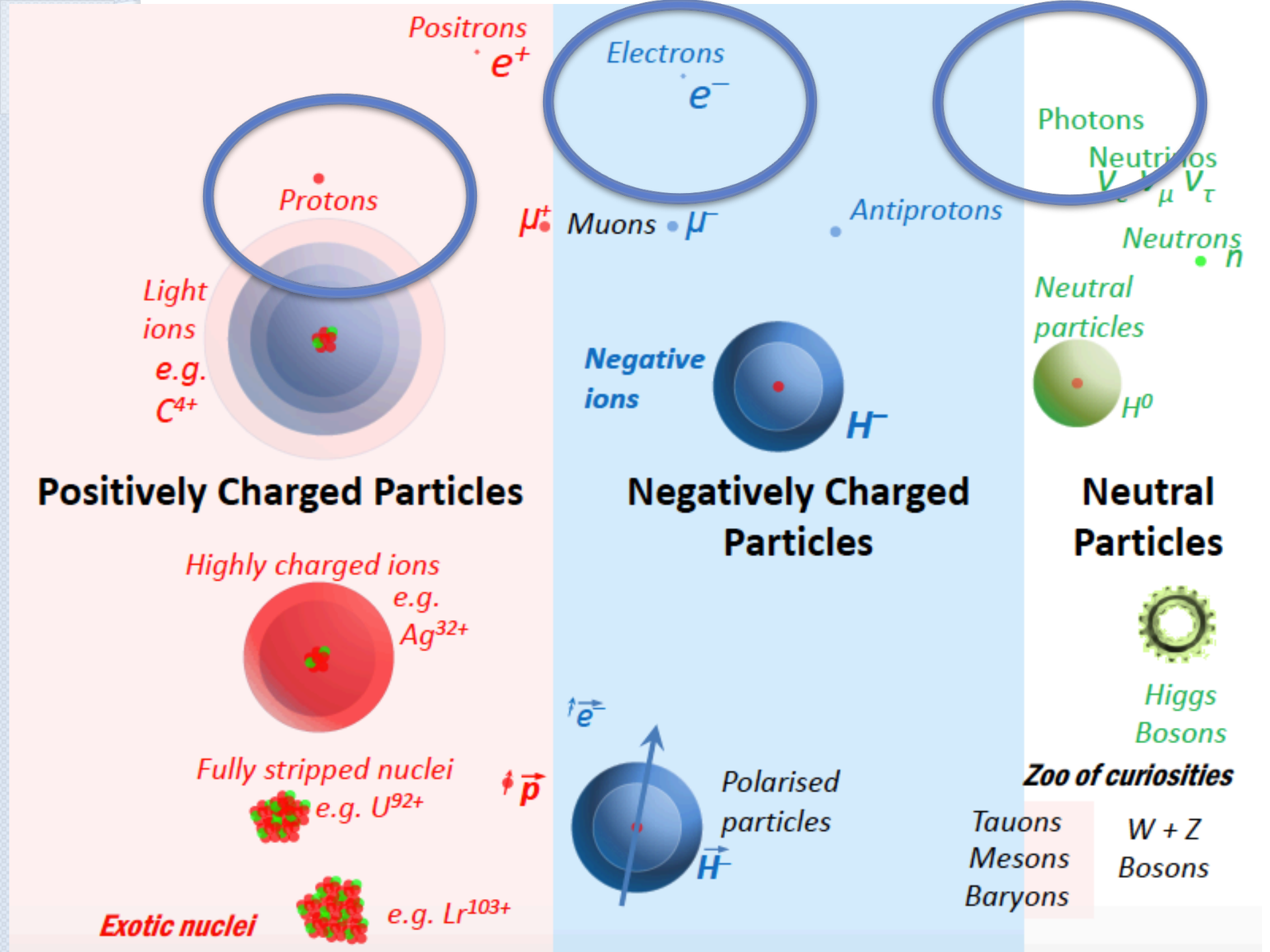
Fuente: CENAVECE/DGAE/RCNA, 2005-2010

*Según Clasificación Internacional de Cáncer en la Niñez

Particle Accelerators Applications

- ✓Sterilizing medical supplies
- ✓Food packing
- ✓Cargo scanning
- ✓Heart valves
- ✓Material hardening for implants
- ✓LINACS




Positrons
e^+
Electrons
e^-
Photons
Neutrinos
ν_e ν_μ ν_τ
Protons
μ^+ Muons μ^-
Antiprotons
Neutrons
$\bar{n}$
Light ions
e.g.
C^{4+}
Negative ions
H^-
Neutral particles
H^0
Positively Charged Particles
Negatively Charged Particles
Neutral Particles
Highly charged ions
e.g.
Ag^{32+}
Higgs Bosons
$\vec{e}$
Fully stripped nuclei
e.g. U^{92+}
$\vec{p}$
Polarised particles
$\vec{H}^-$
Zoo of curiosities
Tauons
Mesons
Baryons
W + Z Bosons
Exotic nuclei
e.g. Lr^{103+}

ESTADO	INSTITUCIONAL	PRIVADO
AGUASCALIENTES	1	1
BCN	2	2
BCS	1	
CAMPECHE	1	
COAHUILA	1	
CHIAPAS	1	
CHIHUAHUA	1	2
DISTRITO FEDERAL	9	8
DURANGO	2	
ESTADO DE MEXICO	1	2
GUANAJUATO	2	
GUERRERO	1	
JALISCO	2	3
MICHOACAN	1	1
MORELOS	1	
NAYARIT	1	
NUEVO LEON	2	3
OAXACA	1	1
PUEBLA	3	2
QUERETARO		1
SAN LUIS POTOSI		1
SINALOA	1	2
SONORA	2	1
TABASCO	1	
TAMAULIPAS	3	
VERACRUZ	2	3
YUCATAN	1	1
ZACATECAS		
T O T A L	41	38

CANCER CENTERS USING LINEAR ACCELERATORS

Oncological Cancer Center in Campeche

Accelerators for medical purposes in Mexico:

Linear accelerators*:

Institution	Number of devices
SSA	25
IMSS	21
ISSSTE	1
Private	23
SEDENA	3
TOTAL	**73**

***Information taken from "Inventario Funcional de Equipos Médicos de Alta Tecnología (EMAT)" presented at 1ª Reunión nacional de responsables de la gestión de equipo médico held in Guanajuato, Mexico from 27-29 May 2015**

Accelerators for medical purposes in Mexico:

- Mexico city: 16 accelerators
- Institutions:
  - Instituto Nacional de Neurología (SSA)
  - Instituto Nacional de Cancerología (SSA)
  - Hospital infantil de México Federico Gómez (SSA)
  - Hospital General de México (SSA)
  - Centro Médico Nacional S. XXI Hospital de oncología (IMSS)
  - Hospital Central Militar (SEDENA)
  - Hospital General de México (SSA)
  - Centro Médico 20 de Noviembre (ISSSTE)
  - Hospital Médica SUR (Private)
  - Centro Médico Dalinde (Private)
  - Hospital Angeles del Pedregal y las lomas (Private)

Accelerators for medical purposes in Mexico:

- Nuevo León: 6 accelerators
- Institutions:
  - Hospital General de Zona No. 25 (IMSS)
  - Centro Universitario Contra el Cáncer (Hospital Universitario de Monterrey, SSA)
  - Hospital General de Zona No 25 (IMSS)
  - Hospital Christus Muguerza (Private)

Accelerators for medical purposes in Mexico:

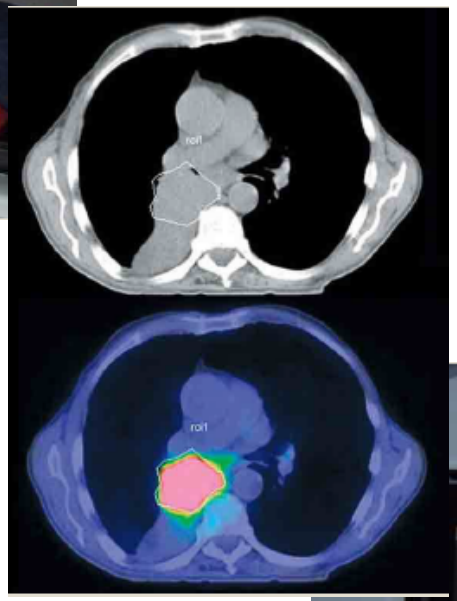
- Puebla: 5 accelerators
- Institutions:
  - Hospital General de Puebla (SSA)
  - Hospital General de Zona (IMSS)
  - Hospital Guadalupe Amor y Bien, Puebla (Private)
  - Pro-Salud de Puebla, A.C. (Private)

Accelerators for medical purposes in Mexico:

- Guanajuato: 2 accelerators
- Institutions:
  - Hospital de Especialidades T1 (IMSS)
  - Hospital Aranda de la Parra (Private)

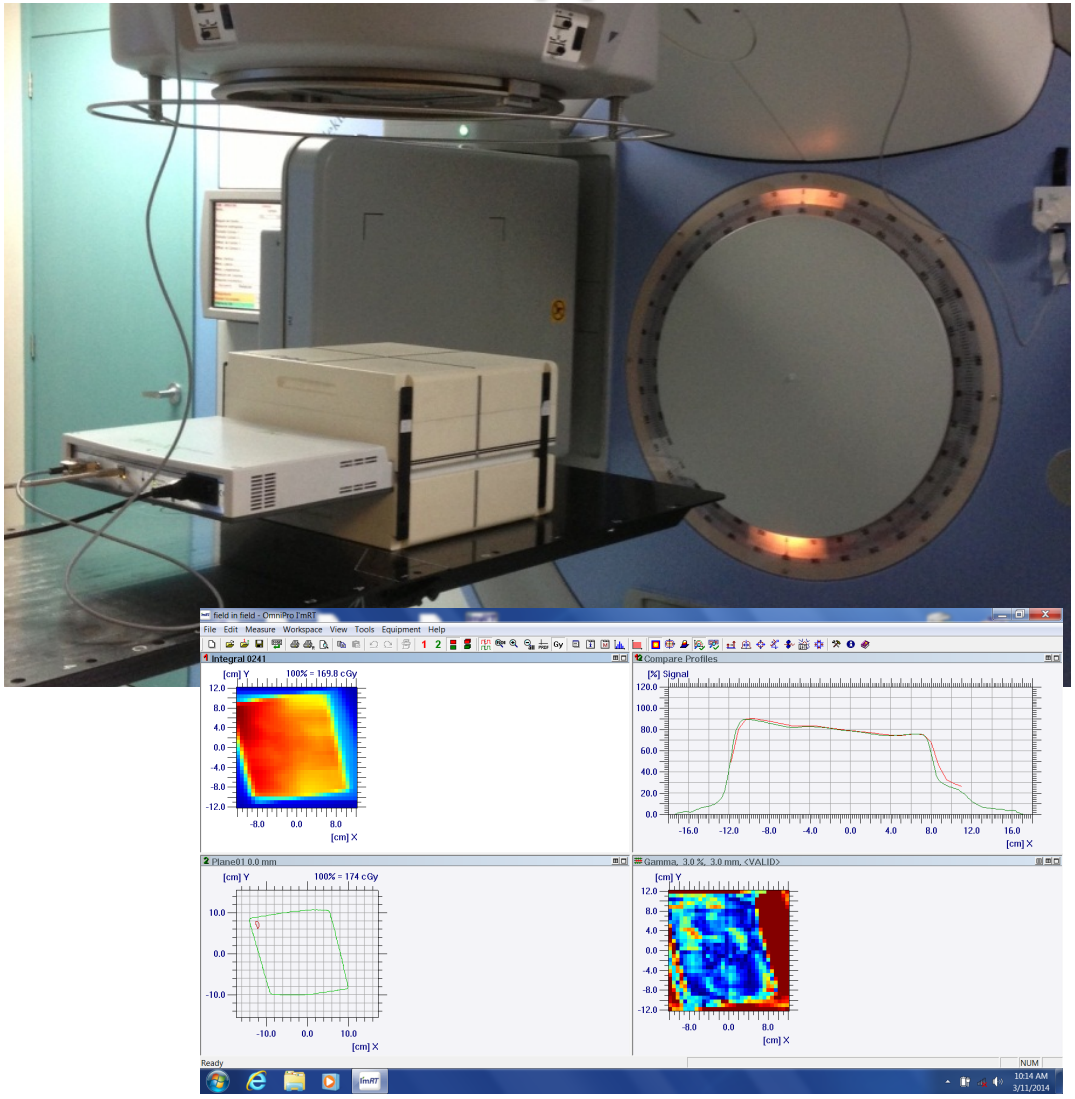
State of the art of Radiotherapy in Mexico

- ✓ Intensity Modulated Radiation Therapy
- ✓ Volumetric Modulated Arc Therapy



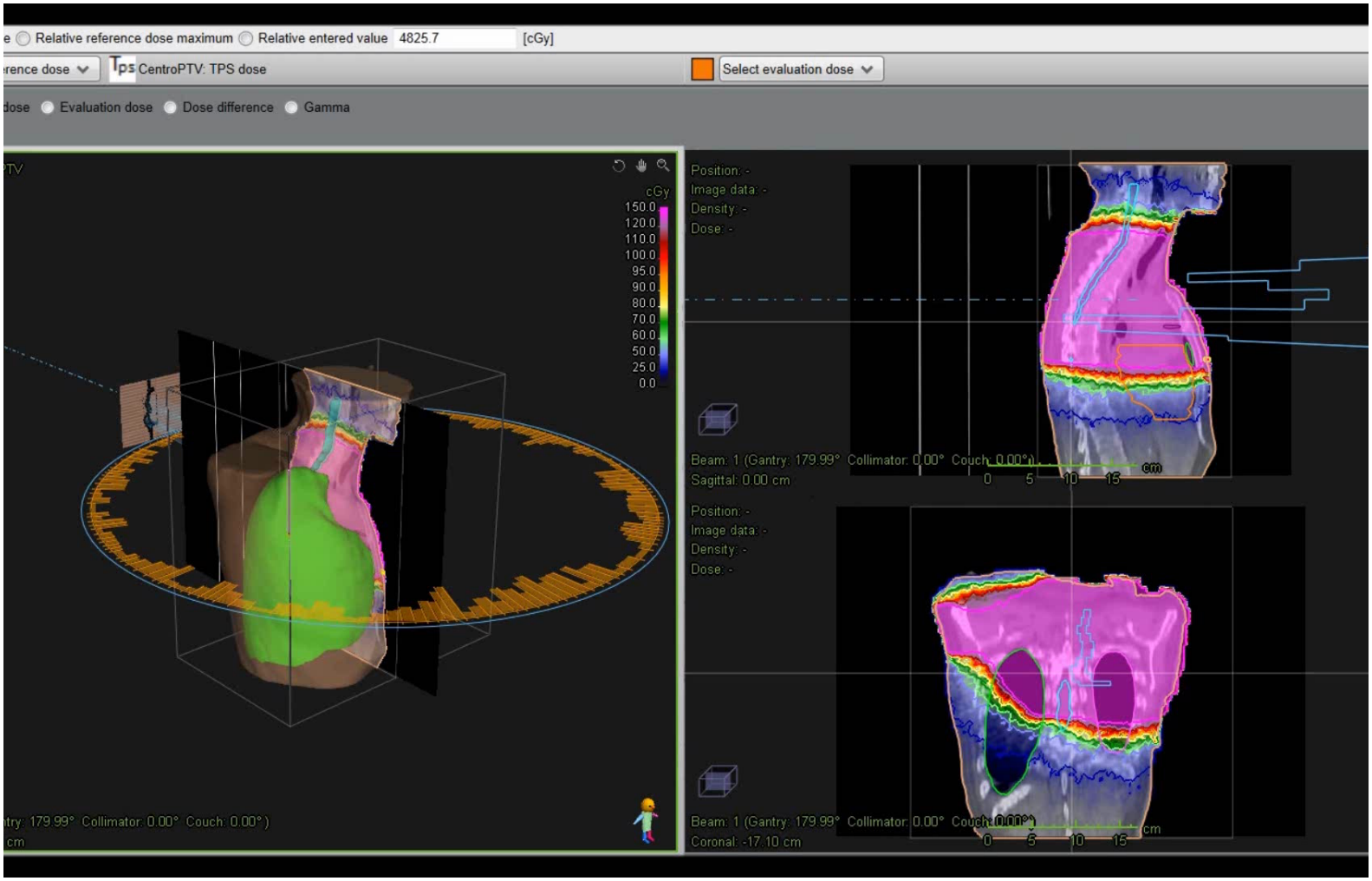
- ✓ Radiosurgery
- ✓ Brachytherapy
- ✓ Special Procedures such as TBI for BMT

Dose verification previous radiotherapy



- ✓ Absolute and relative dose
- ✓ Dose constancy
- ✓ Beam profile
- ✓ Repetition rate, dose rate
- ✓ Dose comparison TPS vs measurement
- ✓ In vivo dosimetry
- ✓ Patient positioning verification
- ✓ Intrafraction and interfraction movement
- ✓ Uncertainties quantification

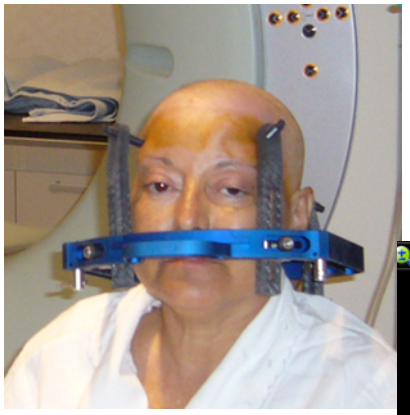
Volumetric Arc Therapy

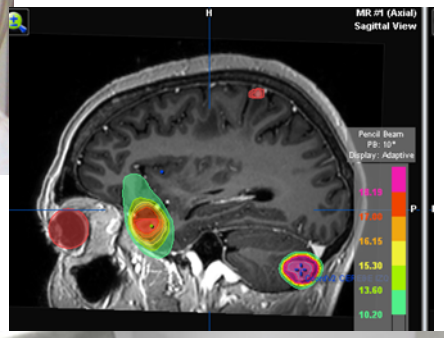


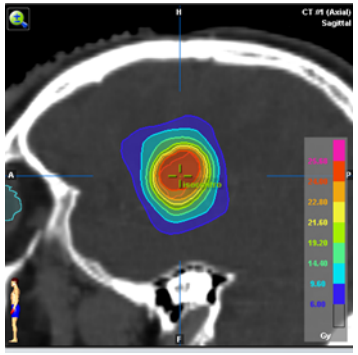
Radiosurgery

- High precision irradiation technique: Stereotactic Precision

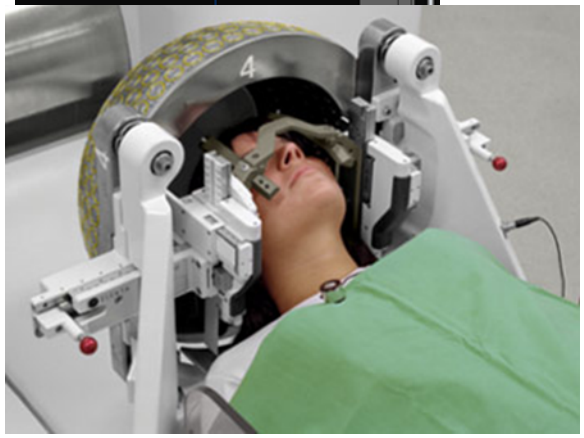
Allows the administration of high dose of radiation per treatment fraction to intracraneal lesions while minimizing the dose to surronding healthy tissue

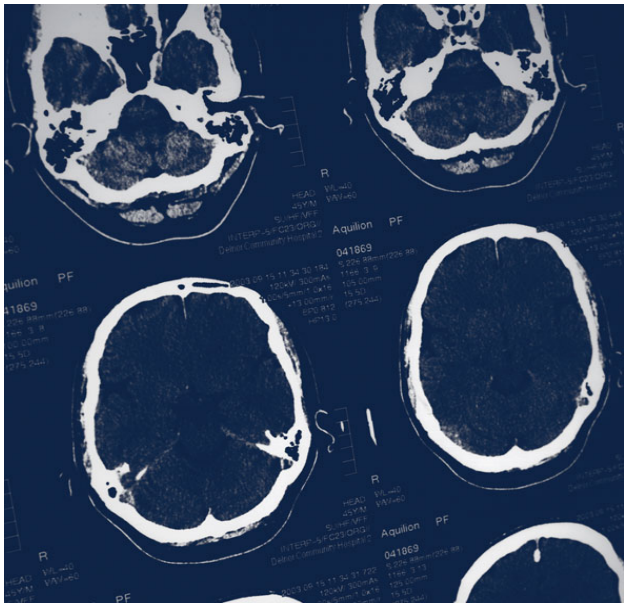






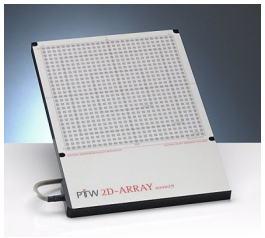
One single treatment session or few sessions

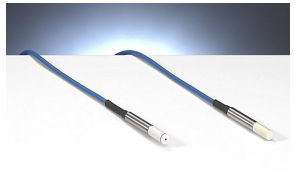




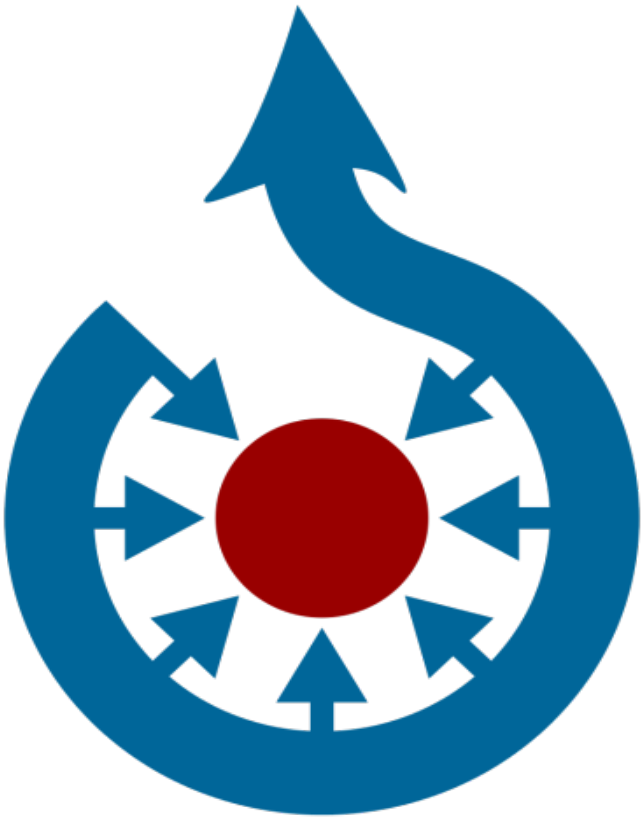
- ✓ Dosimetry in radiotherapy, nuclear medicine and diagnostics

- ✓ Quality Assusrance
- ✓ Quality Controls
- ✓ Radiation safety and security
- ✓ Clinical protocols
- ✓ Special treatment procedures
- ✓ Education and training
- ✓ Medical Management of Radiation Incident Victims

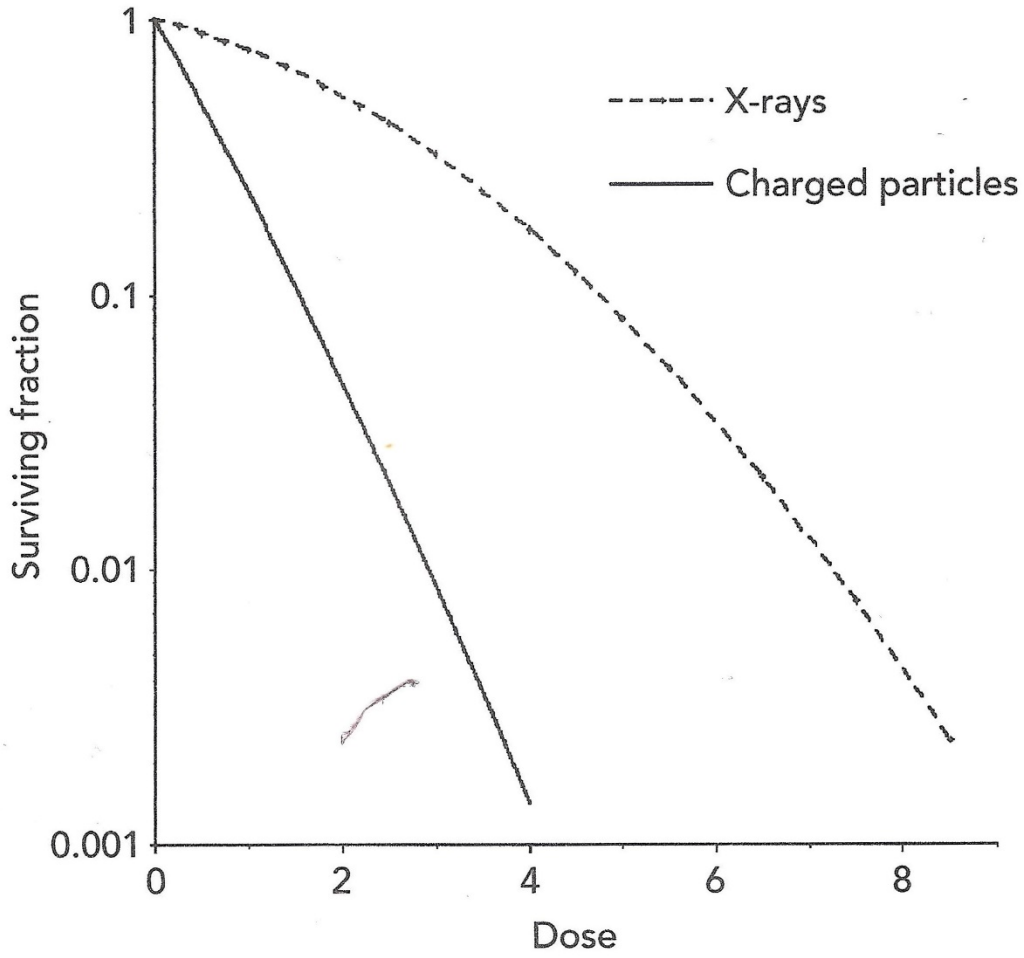




Evaluation Of The Need For a Proton Therapy Facility in Mexico



Survival Curves

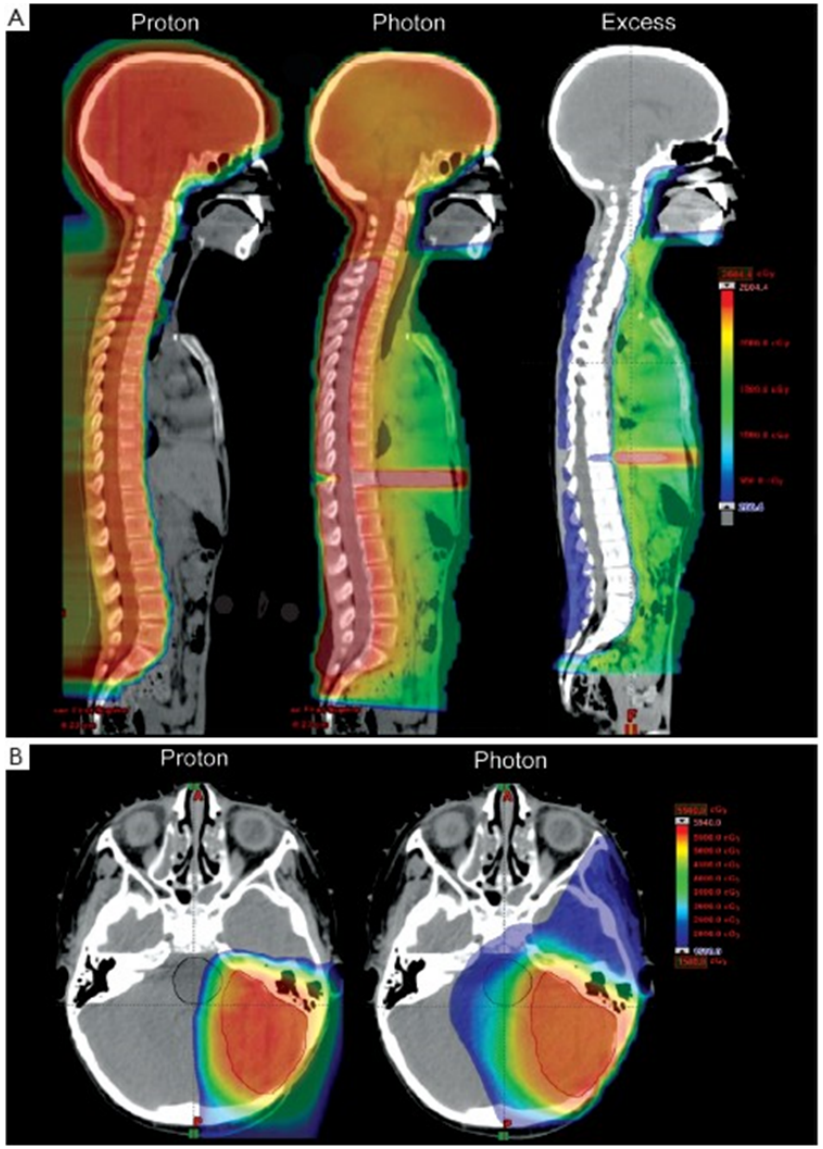


Less tumoral cells

Less administered dose

PEDIATRIC MEDULLOBLASTOMA

Proton therapy is the standard of care



Side Effects*	Protons	Photons
Restrictive Lung Disease	0%	60%
Reduced exercise capability	0%	75%
Abnormal EKGs	0%	31%
Growth abnormality	20%	100%
IQ drop of 10 points at 6 yrs	1.6%	28.5%
Risk of IQ score < 90	15%	25%

PROTON TREATMENT OPTIONS

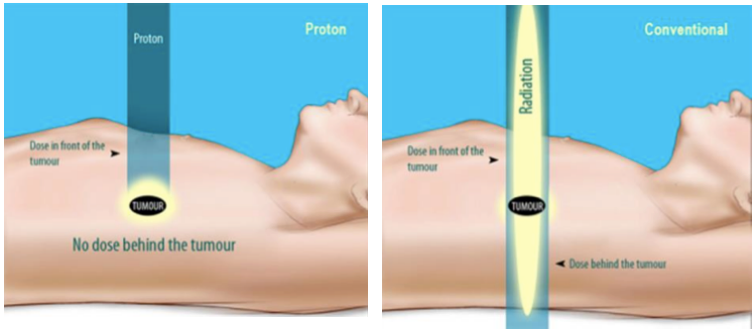
- PROSTATE CANCER
- LUNG CANCER
- PANCREATIC CANCER
- LIVER CANCER
- HEAD AND NECK CANCER
- MELANOMA UVEAL
- SARCOMAS
- LYMPHOMA
- HODGKIN LYMPHOMA

BRAIN TUMORS

- GLIOBLASTOMA MULTIFORME
- GLIOMAS
- TUMORS OF THE SKULL BASE
- MENINGIOMAS
- CHORDOMAS

PEDIATRIC TUMORS

- CRANIOPHARYNGIOMA
- *MEDULLOBLA*STOMA
- EPENDIMOMA
- RETINOBLASTOMA
- RHABDOMYOSARCOMA N
- NEUROBLASTOMA



PROTON THERAPY ADVANTAGES

Dutch Report

Large potential of indications

Standard : **0.6%** of RT

- **Eye**
- **Pediatrics**
- **Base fo Skull**
- **Brain**

Improved Local Control : **3%** of RT

- **Intracranial**
- **Head & Neck**
- **Urologic (prostate & bladder)**
- **Lung (NSCLC)**
- **Sarcoma**

RCT or Individual + Reirradiation

4 Categories of Indications 17.7% of RT patients

Reduced Side Effects : **12.1%** of RT

- **Intracranial**
- **H&N**
- **Urologic**
- **Lung**
- **Breast**
- **Gynecological**
- **GI (Esophagus, gastric, rectal, pancreas)**
- **Lymphoma**
- **Sarcoma**

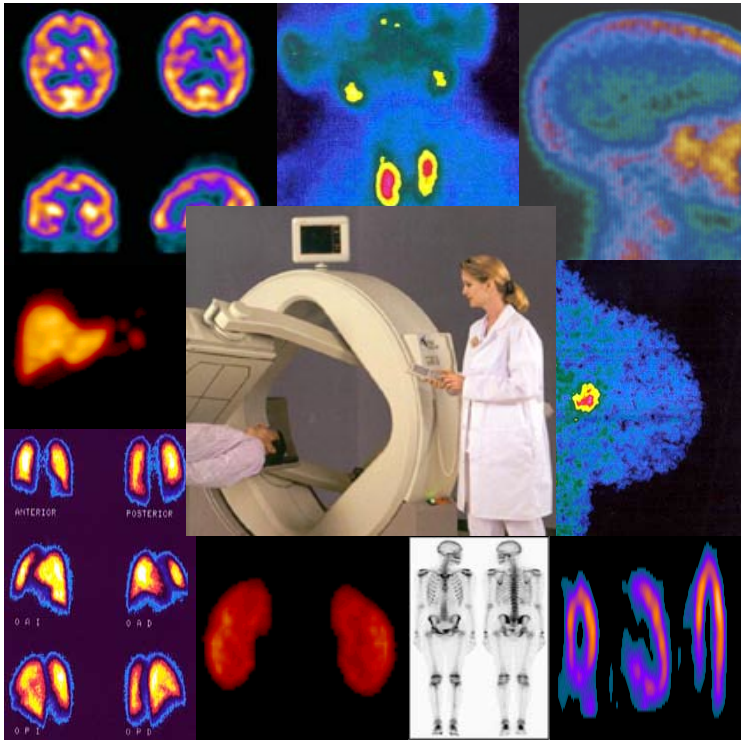
➔ **« Model Based »**

Reduced 2nd Cancers : **2%** of RT

- **Breast**
- **Lymphoma**
- **Testis**

CENTER OF EXCELENCE IN NUCLEAR MEDICAL PHYSICS AND HADRONTHERAPY

- ✓ Our scope is to fulfill the need of nuclide production and proton therapy within the region of south-east Mexico for Clinical and research purposes
- ✓ Fabricate tumor tracers for commercialization
- ✓ Perform diagnostic studies for the private and public health sector
- ✓ Apply proton therapy for cancer treatment
- ✓ Increase research on nuclear applications at our institution
- ✓ Become a center of reference for
- ✓ Human resource training in the nuclear medicine field



PET Imaging need @ Public Health Care Centers (Puebla case)

El Sol de Puebla **Puebla**

Puebla, Mex. | Lunes, 10 de Marzo de 2014

Inicio Puebla Municipios Policiaca Deportes México Internacional Finanzas Opinión Cultura

Es IMSS San José primer lugar en trasplante de células hematopoyéticas

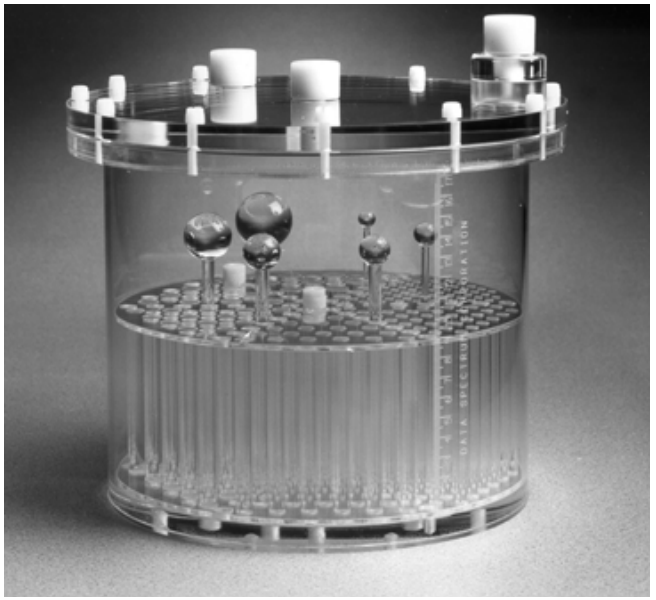
- Only in 2014, 107 new hematologic patients needed at least one PET scan. From those, just 6 were performed.
- Also in 2014, 1200 oncologic patients needed one initial PET scan and at least 1-3 follow up.
- The financial resources are limited to offer only 10-12 PET scans a year.

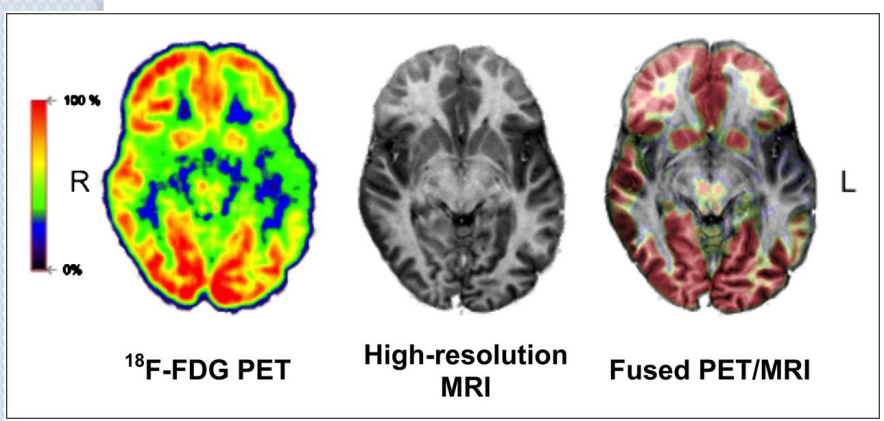
PET Imaging need @ IMSS Puebla

- Locate the site of the cancer
- Determine the size of the tumor
- Differentiate benign from malignant growths
- Discover if the cancer has spread
- Select treatments that are likely to

be appropriate

- Monitor the success of therapy
- Detect any recurrent tumors

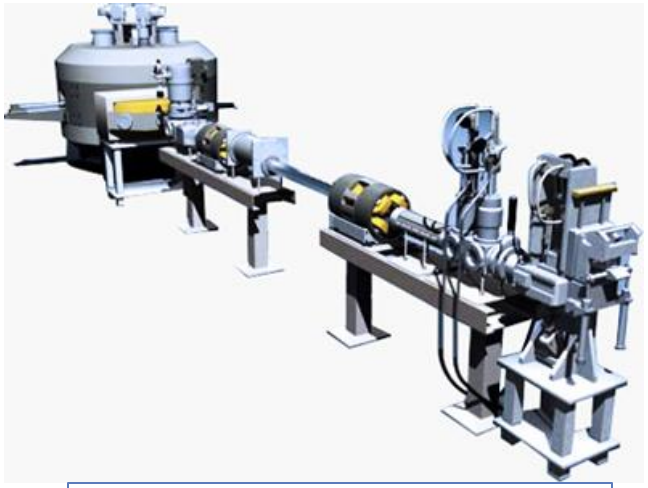




Types of Radionuclides

Proton energy (MeV)	Radionuclide easily produced
0 – 10	18F, 15O, 86Y. 89Zr
11 – 16	11C, 64Cu, 18F, 13N, 15O
17 – 30	123I, 67Ga, 111In, 11C, 18F, 166Ho, 125I, 13N, 15O, 82Sr(82Rb), 186Re, 201Tl
30+	11C, 64Cu, 18F, 67Ga, 68Ga(68Ge), 123I, 111In, 13N, 15O, 82Rb, 82Sr(82Rb), 89Sr, 86Y, 90Y, 89Zr
100+	149Tb, 161Tb (PSI, ISOLDE @ CERN)
Reactor Produced	67Cu, 131I, 133Xe, 223Ra, 177Lu, 186Re, 153Sm, 90Y, 32P, 33P, 166Ho

Main equipment



Ciclotron 1 for Nuclide Production

Radiopharmacy

Cyclotron 2 for proton injection

2 Gantries

Backup equipment for proton therapy

Linac

MRI

hyperthermia

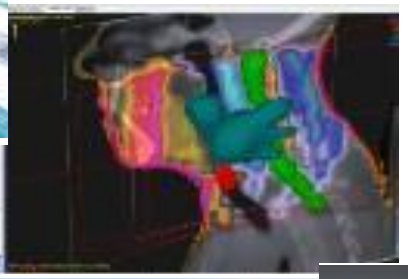
PET/Gamma Camera

CT

Available Human Resources

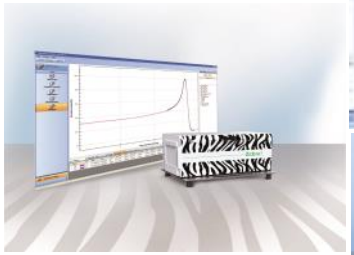
Radiation Oncologists

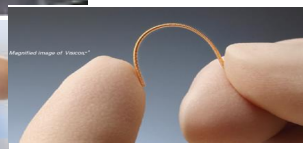
Medical Physicists



Engineers

Dosimetrists





Radiation Technologyst

Chemists

Radiation Safety Officers

CENTER OF EXCELENCE IN NUCLEAR MEDICAL PHYSICS AND HADRONTHERAPY

Founding Institutions: ***BUAP, IMSS, INCAN, MCTP, University of Guanajuato, UAS, CINVESTAV***

Researchers involved: ***Dr. Arturo Fernandez Tellez (FCFM - BUAP), Dr. Mauro Napsuciale Mendivil (Dept. of Physics, A Guanajuato), Dr. Eduardo Gómez Conde (IMSS-Puebla), Dr. Guillermo Tejeda Muñoz (IMSS -Puebla) , Dr. Ramiro Portillo (IMSS - Puebla), Dr. Salvador Reyes Salinas (IMSS - Puebla), M.C . Eva Medel Baez (IMSS - Puebla), Luis Alfonso Adel Alvarez (HU -BUAP), Dr. Eduardo Brambila (BUAP Chemical Sciences), Dr. Daniel Cruz (F. Chemical Engineering), Dr. Benito de Celis (FCFM -BUAP), Dr. Pedro Podesta Lerma (UAS), Dr. Humberto Maury (UdeGto), Dr. M. Gonzalez Blanco(Hospital Angeles), Javier Altamirano (Fac. Medicina, UNAM), Lorena Magallanes (HIT), Jose Ramos (USF).***

Concluding Remarks

- The Mexican Medical and Scientific Community is strongly supporting this proposal. Support by Mayo Clinic and PSI Radiation Oncologist.

- Certain percentage of the total investment have been assured; the rest is being negotiated by contacting public and private agencies as well as foundations.

- Educational Programs towards the training towards strengthening the diagnosis and treatment of oncologic care. Joint efforts by: MCTP, ICTP, AAPM, IOMP, IAEA, and industry.

IAEA Programme of Action for Cancer Therapy PACT

AAPM

ICTP The Abdus Salam International Centre for Theoretical Physics

International Organization for Medical Physics IOMP