Accelerator R&D activities in Spain

(by a none expert but enthusiastic user)

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IFIC-València

TIARA MidTerm meeting at CIEMAT, Madrid June 12-14 2012

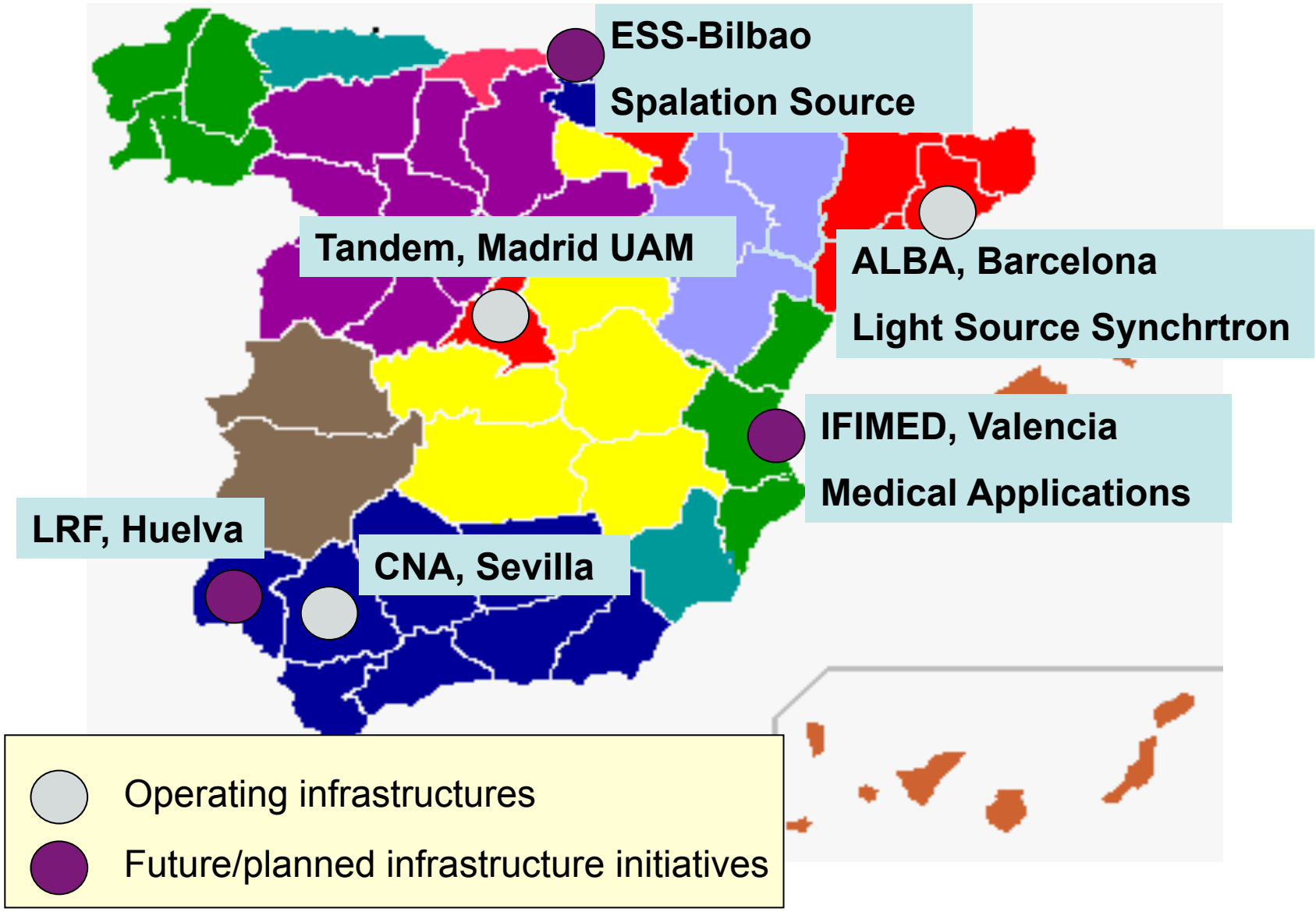
Many thanks to:

J. Bernabéu, J. Bermejo, A. Climent, A. Faus-Golfe,
L. García-Tabarés, J. Gómez-Camacho,
I. Martel, R. Pascual

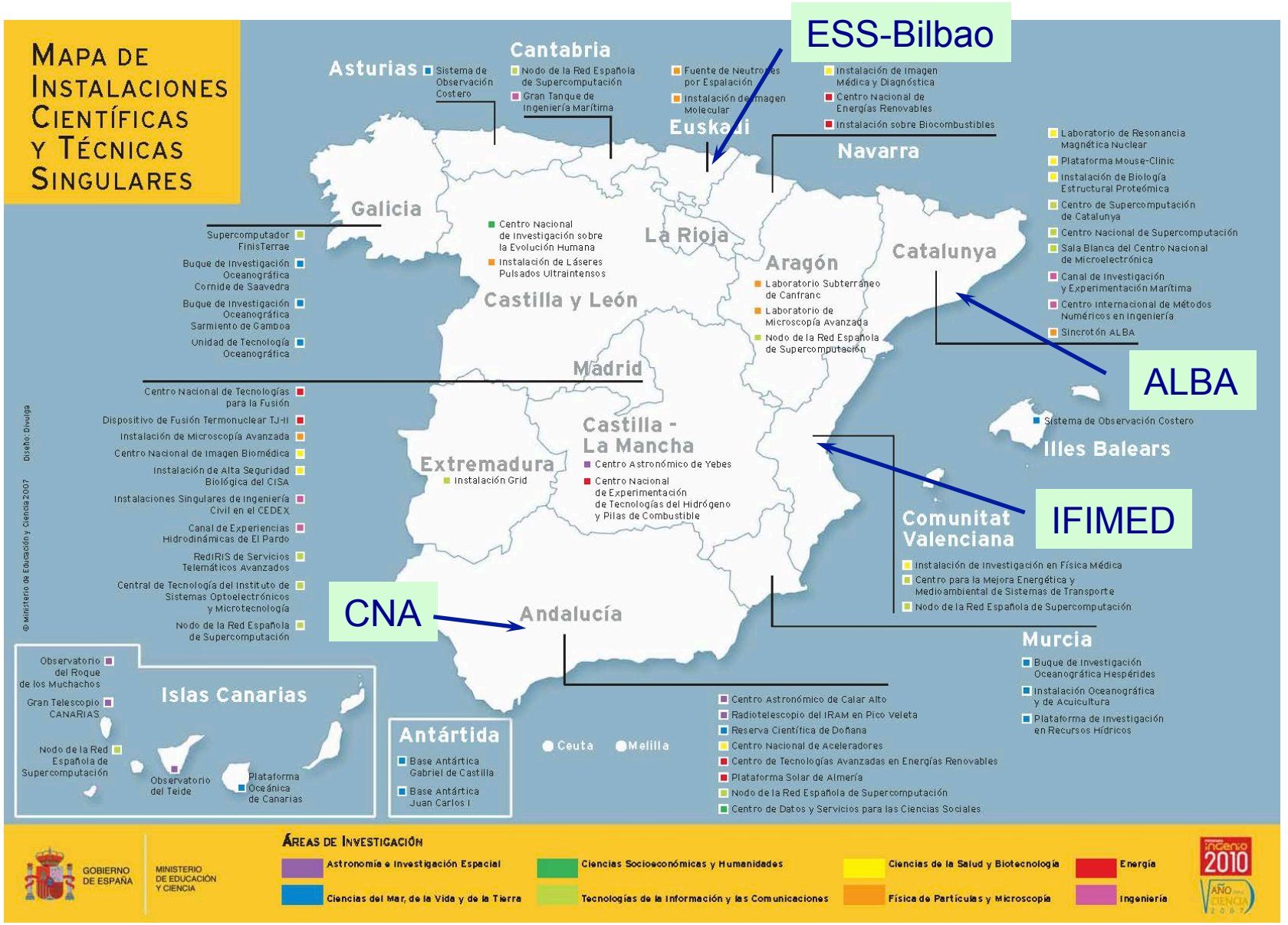
Outline

- **Spanish accelerator Infrastructures:**
  - Infrastructures in operation:
    - ALBA (Barcelona)
    - CMAM (Madrid)
    - CNA (Sevilla)
  - Infrastructures in construction
    - ESS-Bilbao
  - Infrastructures in consideration or preparatory phase
    - LRF-Huelva
    - IFIMED (Valencia)
- **R&D accelerator activities**
    - CIEMAT (Madrid)
    - IFIC (Valencia)

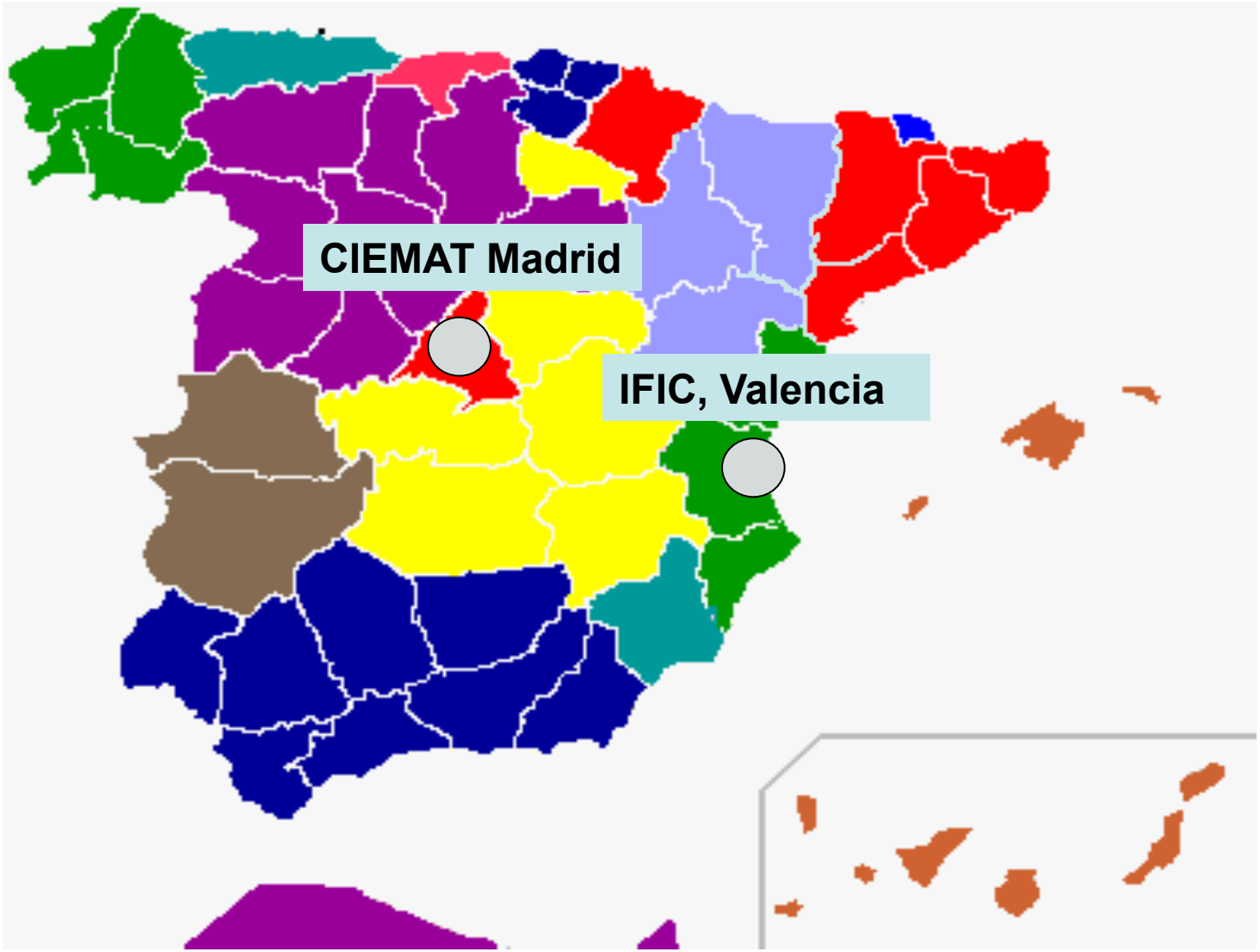
Accelerator Infrastructures



Spanish Infrastructures Roadmap: ICTS – Ingenio 2010



Institutes/labs with R&D accelerator groups



The ALBA Synchrotron Light Facility

"A long and winding road"

First proposal in 1992

…….

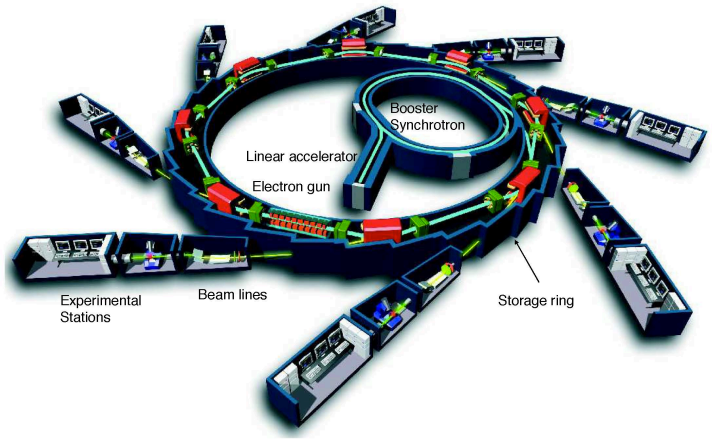
Inaugurated in 2009

2012, present

in successful operation

(a lesson for future initiatives)

Accelerator complex to produce SR



The ALBA Synchrotron Light Facility

Main characteristics of SL

Continuous Spectrum, from infrared to X-rays, with

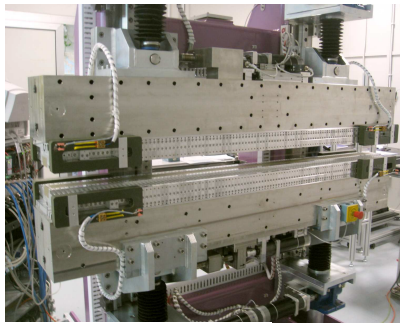
E_{crit} (keV) = 0.665 E^2 (GeV) B(T)

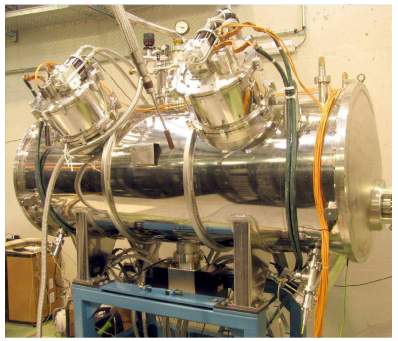
Intense, as a narrow beam

ϑ(rad) = 0.51/E (MeV)

Polarized in the orbital plane

With **temporal structure**

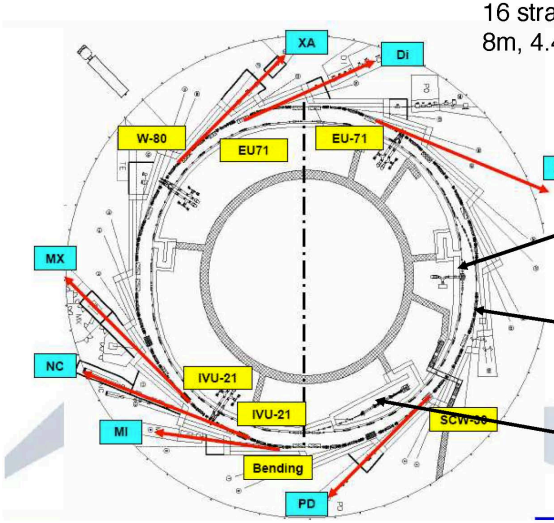




electrons

photons

3rd generation sources:
wiglers and ondulators

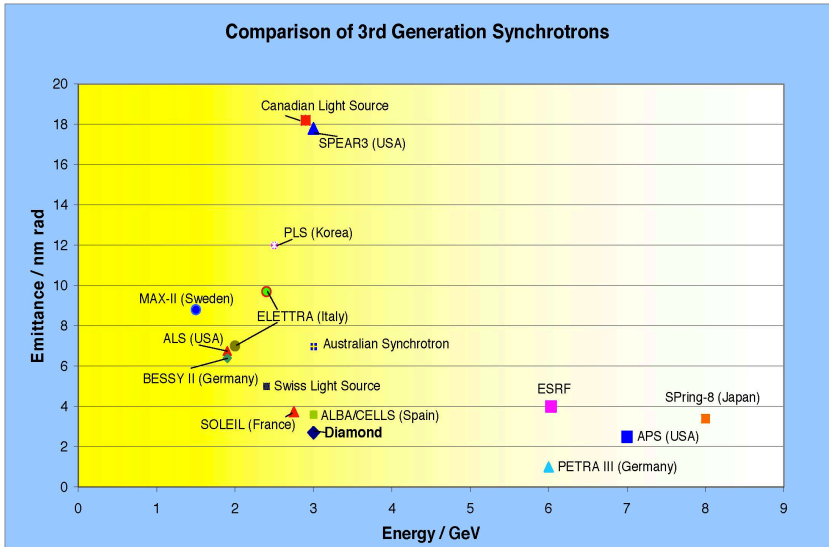


16 straight sections of
8m, 4.4m and 2.6 m long

Booster: 3 GeV, 250 m
4 fold symmetry
emittance smaller **20 nm·rad**

Storage ring: 268 m
double bend achromat lattice
16 cells with 4 fold symmetry

Linac: 100 MeV
At 3 GHz
Repetition rate of 3Hz



The ALBA Synchrotron Light Facility

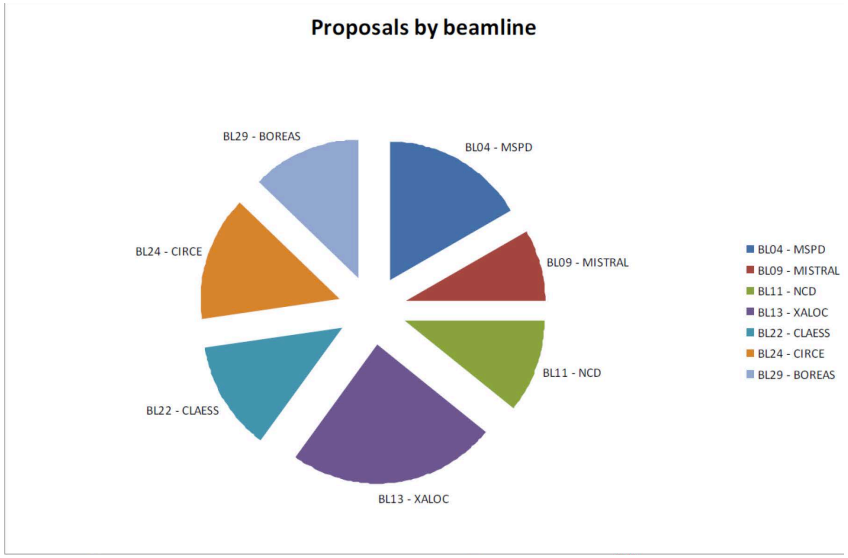
First phase of beamlines

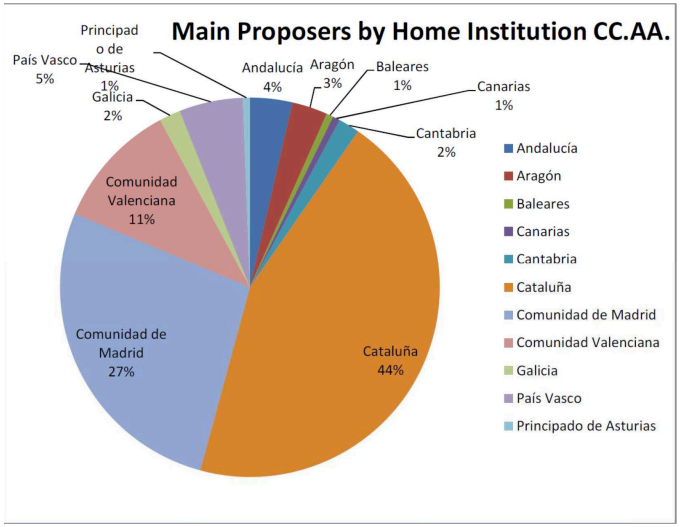
Port	Beam-line	Experimental techniques	Scientific applications
4	**MSPD** (SCW-30)	Materials Science and Powder Diffraction	Structure of Materials, Time resolved diffraction
9	**MISTRAL** (BM)	X-ray microscopy.	Cryogenic tomography of biological objects. Spatially resolved spectroscopy
11	**NCD** (IVU-21)	Non-Crystalline Diffraction	Structure and phase transformations of biological fibers, polymers, solutions. Time resolved X-ray studies
13	**XALOC** (IVU-21)	Macromolecular Crystallography	Protein crystallography, with particular emphasis on large unit cell crystals
22	**CLÆSS** (MPW-80)	Core Level Absorption & Emission Spectroscopies	Material Science, Chemistry, Time resolved studies
24	**CIRCE** (EU-62)	Photoemission Spectroscopy and Microscopy Photoemission microscopy (PEEM) Near atmospheric pres. Photoem. (NAPP)	Nano-science and magnetic domain imaging (PEEM). Surface chemistry (NAPP)
29	**BOREAS** (EU-71)	Resonant Absorption and Scattering	Magnetism, surface magnetism and magnetic structure

Results of the first call for users

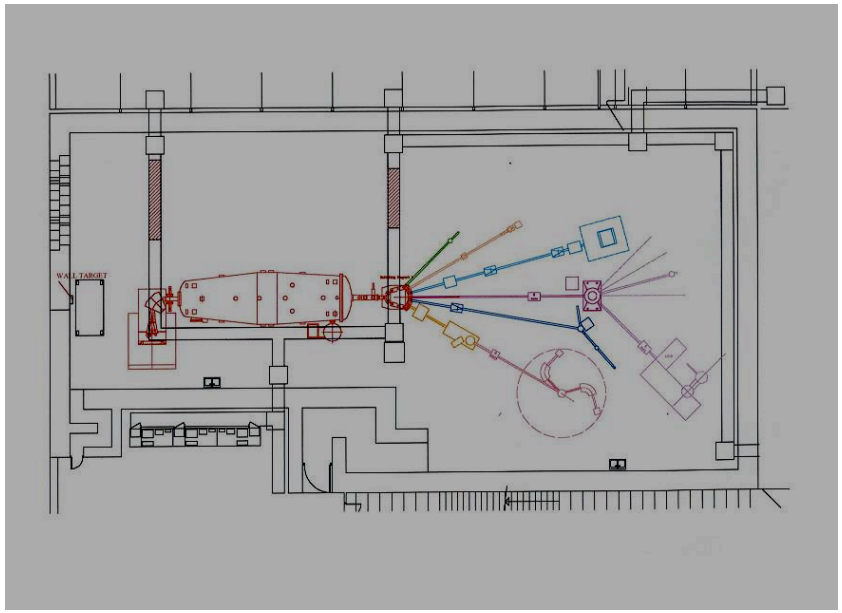
- **200 proposals received**
- **636 registered researchers**
- **All the BLs (x7) have a high numeber of proposals**

- **82% are Spanish proposals**
- **16% are EU proposals**
- **3 are no UE proposals**



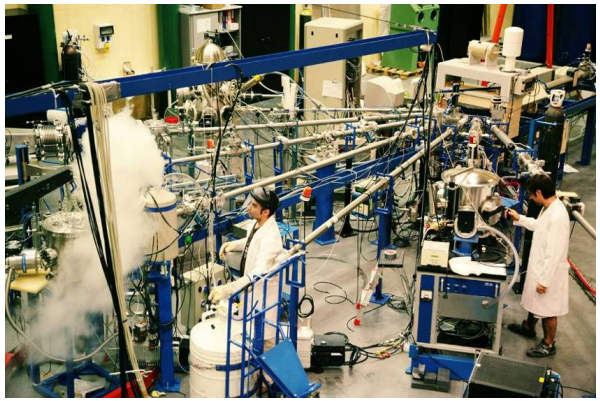


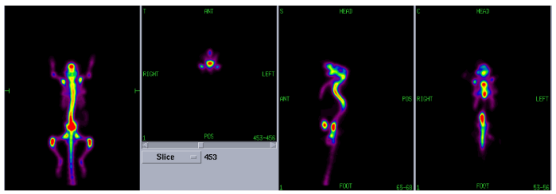
CMAM: Centre for Micro-Analysis of Materials



- **Centro de Micro-Análisis de Materiales is a research laboratory with an electrostatic accelerator for ions at UAM.**
- **A 5 MV parallel fed Cockcroft-Walton.**
- **It is in operation since 2002 covering:**
  - Analysis of materials using ion beam analysis (IBA) technics applied in different fields of knowledge.
  - Applications based on the modifications of the properties of materials by ion irradiation and implantation
  - Basic studies on ion matter interaction
  - Provides service to external users managed by the Parque Científico de Madrid

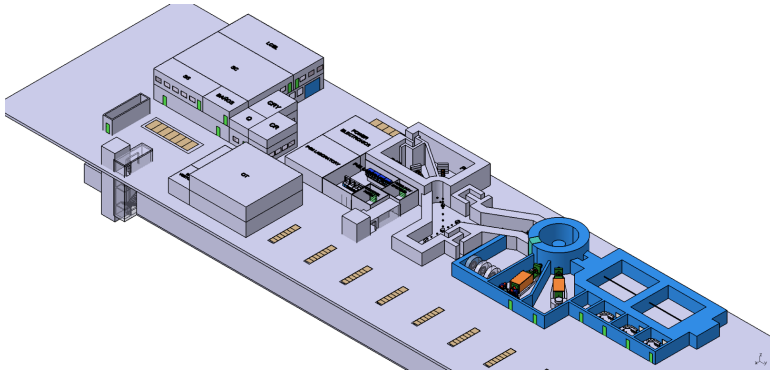
CNA: Centro Nacional de Aceleradores

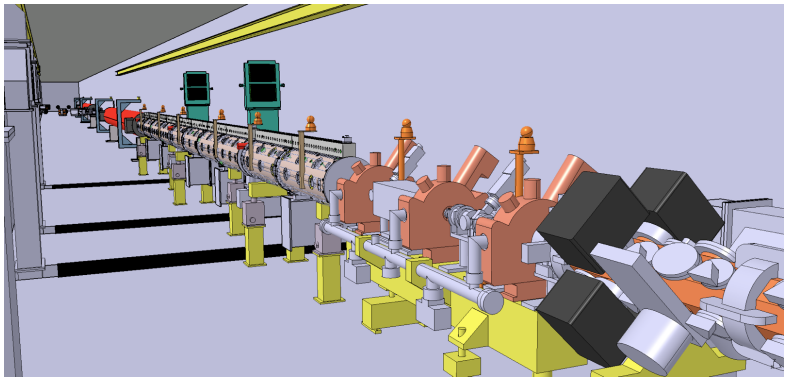


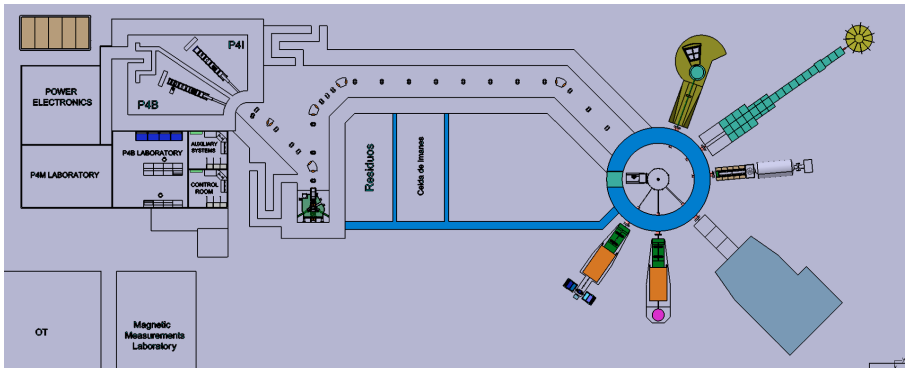


- **Centro Nacional de Aceleradores (US, JA, CSIC). It includes:**
  - 3 MV Van de Graf tandem
  - 1 MV Cockcroft-Walton tandem.
  - 18 MeV Cyclotron
- **Main activities:**
  - Material science
  - Applications to environmental science
  - Basic science: instrumentation, nuclear physics
  - Dating using ^{14}C technique
  - Radio pharmacy
  - Bio-medical research

EES-Bilbao: European Spalation Source Bilbao







The ESS-Bilbao (ESSB) light ion linear accelerator has been conceived as a multi-purpose machine, useful as the core of a new standalone accelerator facility in southern Europe giving support to local beam users and accelerator physicists, as well as fulfilling specifications so as to serve as a driving injector for the European Spallation Source (ESS) once this latter project gets off the ground.

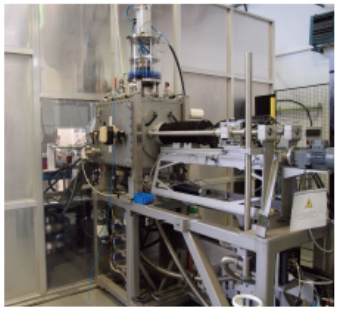
EES-Bilbao machine parameters

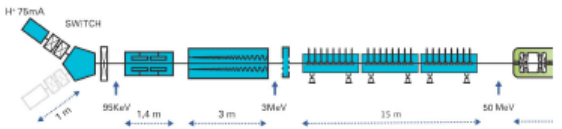
Tabla 2.1: Parámetros básicos de la instalación

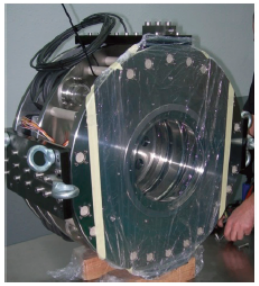
Máxima energía cinética del haz	60	MeV
Corriente máxima	75	mA
Frecuencia máxima de repetición	30	Hz
Frecuencia de paquetes (bunches)	352.2	MHz
Máxima duración del pulso	1.8	ms
Especies a inyectar	H^+ y	H^-
Longitud elementos de aceleración	29.5	m
Emitancia normalizada en extracción (T)	0.34 π mm mrad	(norm.)
Emitancia normalizada en extracción (L)	0.20 π ° MeV	
	0.50 π mm mrad	(norm.)
Número total de klystrons	4	2.8 MW en pico
Eficiencia de RF	0.85	
Errores tolerables		
En gradiente de cuadrupolos	$\pm$0.5 %	
En posición	$\pm$0.1 mm	
En alineamiento angular	$\pm$ 0.5° (x,y)	0.3° (z)
En fase cavidades RF	$\pm$ 1 °	
En amplitud cavidades RF	$\pm$1 %	
Transporte a blancos		
Malla óptica	FODO	7 m
Número total de celdas	5	
Grad. max. cuadrupolo de trasporte de haz	2.08 T m^{-1}	
Disp. extracción	kicker	dipolo
Blanco de generación de neutrones		
Material	Be metálico	100 % ^{9}Be, 1.848 g cm^{-3}
Estructura	Disco rotatorio	92 cm O.D / 68 cm I.D.
Moderador primario	CH_4	12 cm × 4 cm × 12 cm
Flujo a 10 meV	[n/cm^2-eV-Sr-MW]	8.09 × 10^{11}
Moderador intercambiable	$p-H_2$	12 cm × 12 cm × 14 cm
Flujo a 10 meV	[n/cm^2-eV-Sr-MW]	1.63 × 10^{12}
Reflector	Be metálico	Cilindro 80 cm∅ × 120 cm

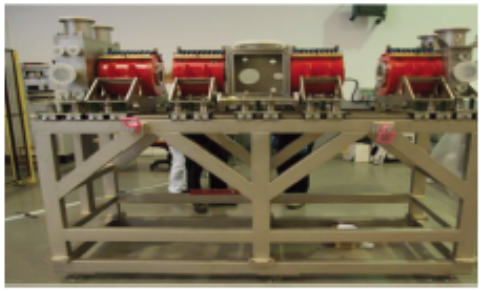
Tabla 2.2: Parámetros básicos de los elementos del acelerador

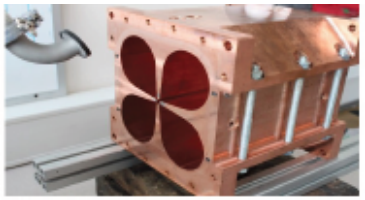
Elemento Unidad	Long. m	Energ. MeV	No. Cavs.	No. Gaps	Pot. RF MW	No.Klystrons
Fuente	1.5	0.075	-	-	-	-
LEBT	4					
RFQ	3.9	0.075 - 3.0	1	560	1.2	1
MEBT	3	3	2	-		
DTL	14.6	3 - 50	3	85	3.8	3
Spokes	3.5	50 - 60	2	4	0.8	1

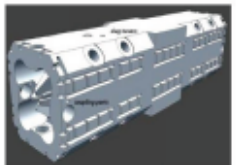


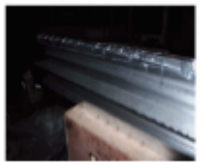












EES-Bilbao: International cooperation

Sinergias con proyectos en construcción

Linac4 – External Contributions, June 2010

Network of agreements to support Linac4 construction

RFQ RF design, RF amplifiers, modulator construction from French Special Contribution. *agreed and started.*

Prototype modulator, RF tuners, couplers, waveguides from India, *in progress*

Agreement with DESY to access drawings of H- source *completed*

Transfer line vacuum chambers and supports from Pakistan, *agreed*

Chopper line built in a EU Joint Research Activity *completed*

Participation of ESS-Bilbao in DTL construction, *agreed and started*

Construction of CCDTL in Russia, via an ISTC Project *agreed and started*

Collaboration agreement with Soltan Institute (Poland) and FZ Julich (D) for PIMS construction, *in preparation.*

SNS High Voltage Pulsed Power Supply Statement of Work (SOW) and Specification

104010200-SW0007, R08

July 2009

NEUTRON SCIENCES

IFMIF EVEDA Accelerator System Group

SLAC NATIONAL ACCELERATOR LABORATORY

ISIS ASTeC WARWICK Imperial College London ESS Bilbao

The Front End Test Stand Collaboration – FETS –

RFQ Assembly
Vane to Vane Alignment_v1
13th January 2012

Spiral2

Existing experimental halls

Existing accelerators

Experimental hall with exotic nuclei at low energy (DESIR)

Experimental hall Super Separator Spectrometer (S3)

Target-Source Ensemble

Experimental hall Neutrons For Science (NFS)

Linear Superconductor Accelerator LINAC

Deuteron - Proton source

ECR Source

NEUTRONS FOR SCIENCE

Institut Laue-Langevin

LENS
The Low Energy Neutron Source

Argonne NATIONAL LABORATORY

LRF-Huelva: Linac Research Facility

The **Linac Research Facility (LRF)** is foreseen to be a user oriented facility for producing intense HEAVY ION BEAMS for basic research on nuclear physics and applications.

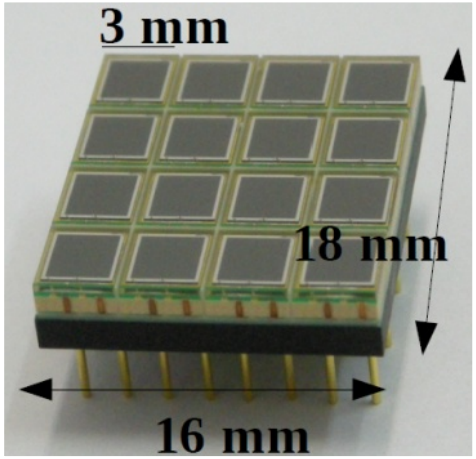
HIGH INTENSITY SUPERCONDUCTING LINAC:

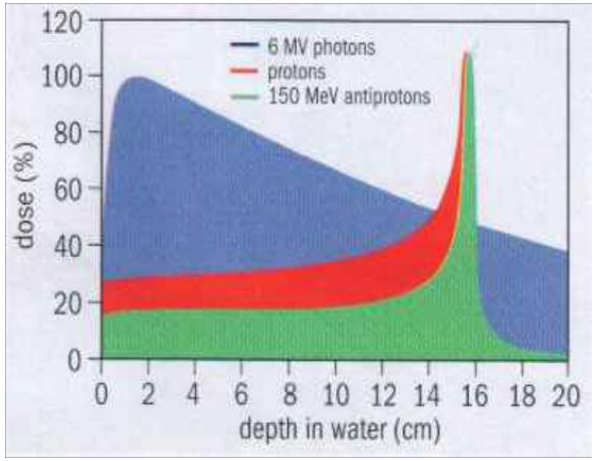
- Wide range of heavy ions
- Wide range of energies, from keV/u ~15 MeV/u
- Maximum intensity for HI (~100uA, ^{40}Ar)
- protons up to 30 MeV (~1 mA); up to 70 MeV (nA)

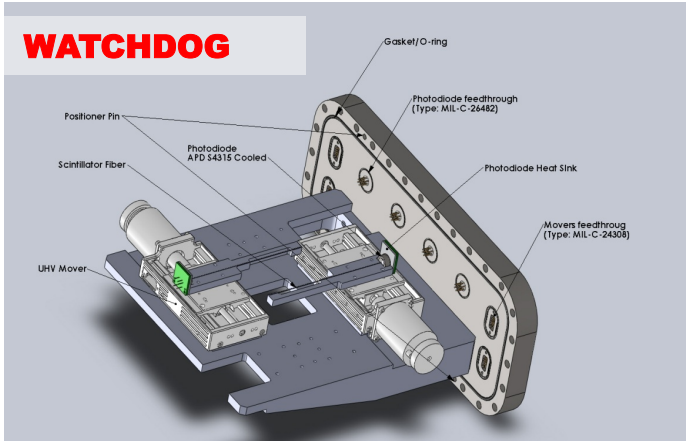
RESEARCH & APPLICATION PROGRAM
Basic nuclear physics: reactions & structure, astrophysics, superheavies; exotic isotopes(IGISOL)
Materials for Fusion and Fission energy
Aerospace
Medical applications: Radioisotopes & Proton therapy

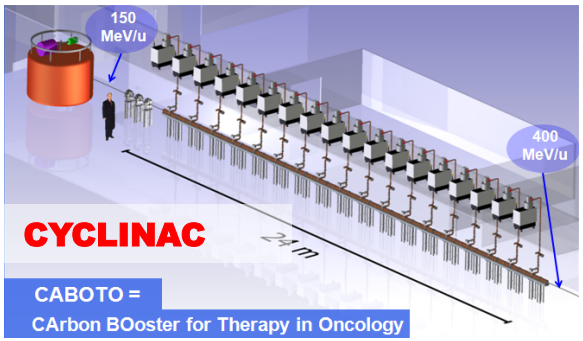
UNIVERSITY OF HUELVA (SPAIN)

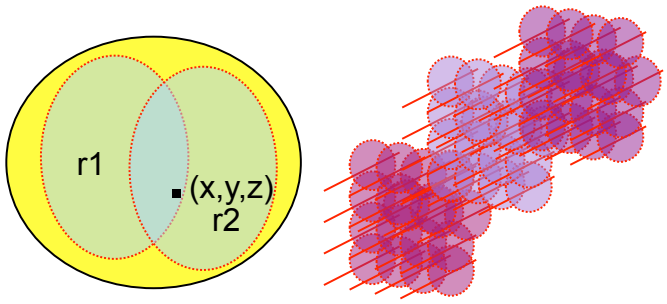
IFIMED: research in imaging and accelerators applied to medicine



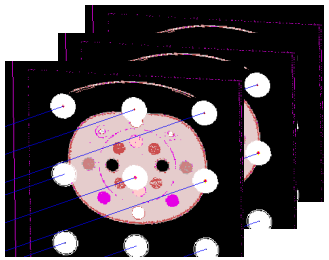








IFIMED is conceived to be the Spanish Reference Centre for Imaging and Particle Accelerators for Medical Physics. The activity of the groups is carried out on an international context: since 2007, IFIMED is a member of ENLIGHT European Platform



Motivation and research in:

- Accelerators for Medical Physics
- Radiation Detectors
- Image Science
- MonteCarlo Simulation in GRID

CIEMAT Accelerator Technology group

In the year 2008, CIEMAT created a Particle Accelerators Unit with 25 people up to now. It absorbs the former Applied Superconductivity Group and the facilities located at another Institute, CEDEX. Presently it is part of the Electrical Engineering Unit where other activities such as Energy Management, are also developed.

Capabilities

- **Calculations**: electromagnetic, thermal and mechanical and beam dynamics simulations
- **Engineering design**
- **Prototyping**: fabrication and assembly of magnets, RF structures and other accelerator devices
- **Tests**: two vertical cryostats, one cryocooler and low power RF measurements

Accelerator R&D activities: CIEMAT

Facilities

Main Offices (Moncloa)

CIEMAT Winding Machine

Energy & Superconductivity
(J. Camarillo)

Accelerators Components (J. Camarillo)

Accelerator R&D activities: CIEMAT

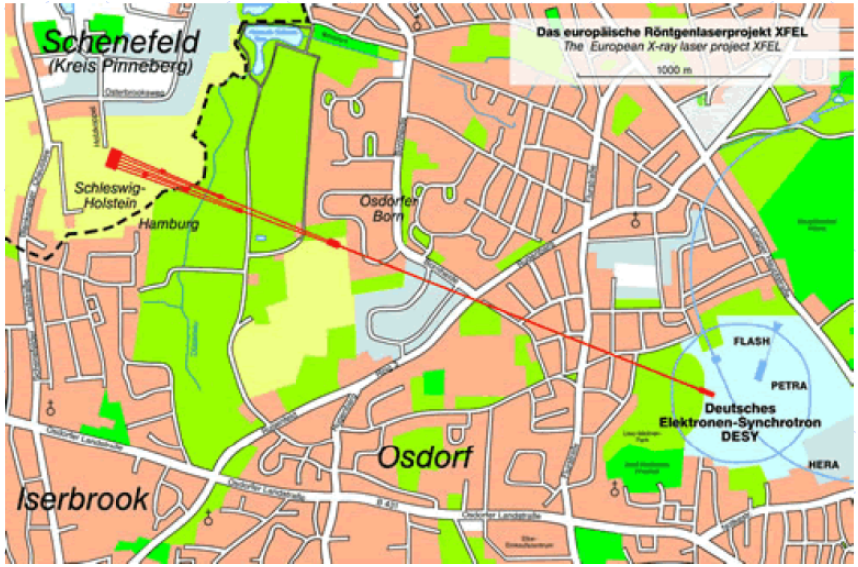
CIEMAT Accelerator Group Activities

Accelerators	Energy
Large Facilities ↓	***Storage*** ↓
XFEL	SA²VE
FAIR	ACEBO
CLIC	TRAIN2CAR
SuperLHC	EERA
ILC (DANTE)	***Production*** ↓
IFMIF	SuperTURBINES
TIARA	SeaWEDGE
Small Accelerators ↓	UNDIGEN
MICROTRON	IISIS
CICLOTRON (AMIT)	

CIEMAT Contribution to the E-XFEL Project

XFEL

The European X-ray Free Electron Laser Facility (E-XFEL) will be based on a 17.5 GeV electron Linac.
Its beam will be used in three undulator systems to obtain ultra-brilliant X-ray flashes from 0.1 to 6 nanometres for experimentation.



CIEMAT Contribution:

LINAC

UNDULATORS

- 83 (+20) Combined Superconducting Magnets
- 91 Phase Shifters
- 91 Closed-Loop Quadrupole Movers

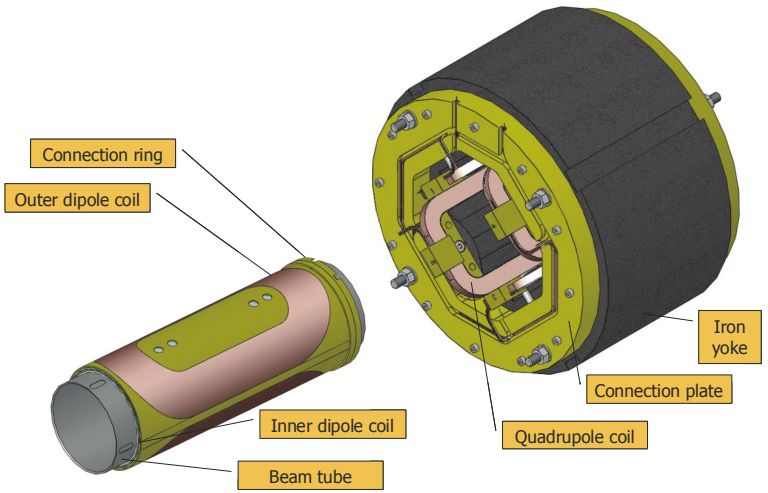
Combined Superconducting Magnets

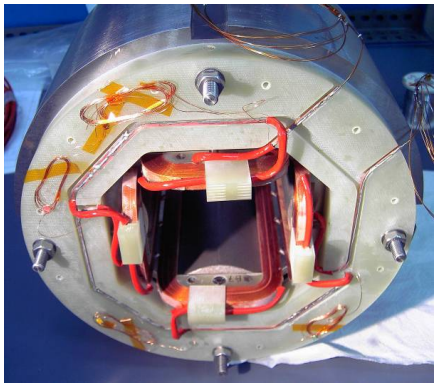
XFEL

The cryomodules of the XFEL linac will be equipped with one combined superconducting magnet package per module, which consists of

- **One Superferric quadrupole** for focusing
- **Two dipoles** (horizontal and vertical) for steering the beam, glued around the beam tube

Both enclosed in a stainless steel vessel.





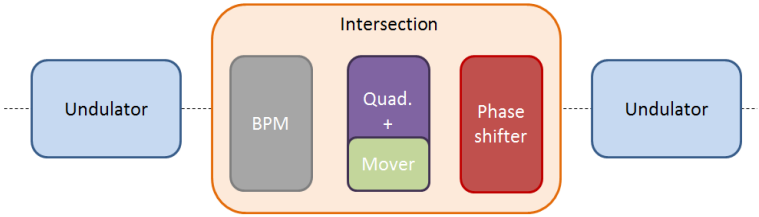
- Five prototypes have been fabricated and several designs have been implemented.
- Series production of 82 superconducting is ongoing
- Production of 20 additional magnets if total energy is increased up to 17 GeV

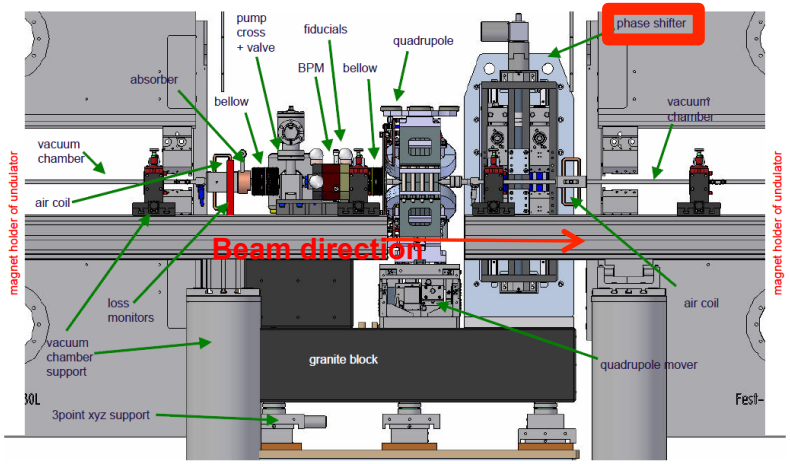
Accelerator R&D activities: CIEMAT

Phase Shifter

XFEL

The undulator systems in XFEL are formed by 5m long undulator segments and 1.1 m long intersections in between. They accommodate a quadrupole on top of a precision mover, a beam position monitor, two air coil correctors and a phase shifter.





Phase shifter

The phase shifter developed by CIEMAT is a permanent magnet device and it will be located at the end of the undulator system intersection.

Goal: To adjust the phase of the electron beam with respect to that of the radiation field when the wavelength is changed by tuning the gap

- A prototype has been fabricated by CIEMAT
- Acceptance tests are being performed at CELLS
- Call for tenders after prototype approval.
- Series production

Quadrupole mover

XFEL

The quadrupole mover with submicron repeatability will be used in the intersections of the Undulator Systems of the E-XFEL. The main specifications include submicron repeatability for a 70 kg quadrupole magnet within compact dimensions and a ±1.5 mm stroke in the vertical and horizontal direction.

MAIN FUNCTIONS

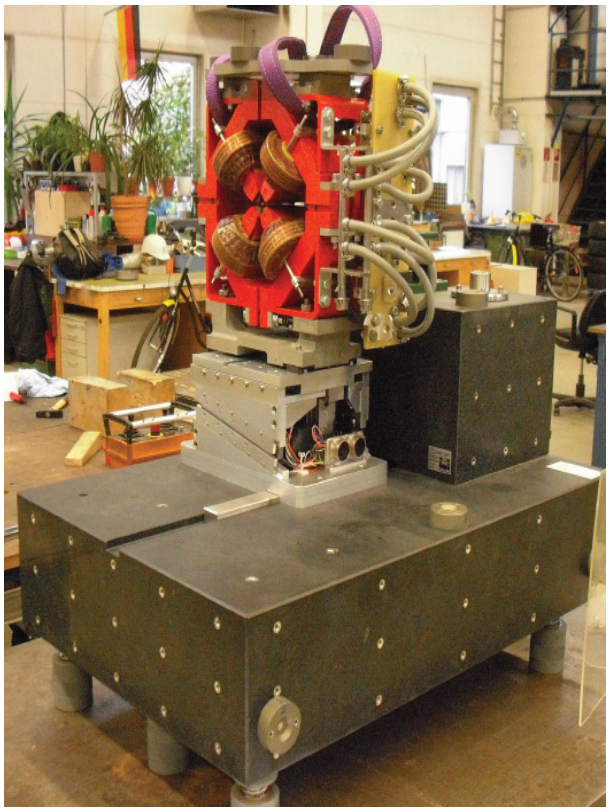
1.-Quadrupole positioning

2.-Off-centring corrections

3.-Quadupole/Intersection tolerances relaxing.

This quadrupole mover for E-XFEL intersections has been evaluated in several tests achieving good results. The pre-series production is ready to start, but official validation from XFEL is pending. It is expected to supply 92 units according to E-XFEL schedule

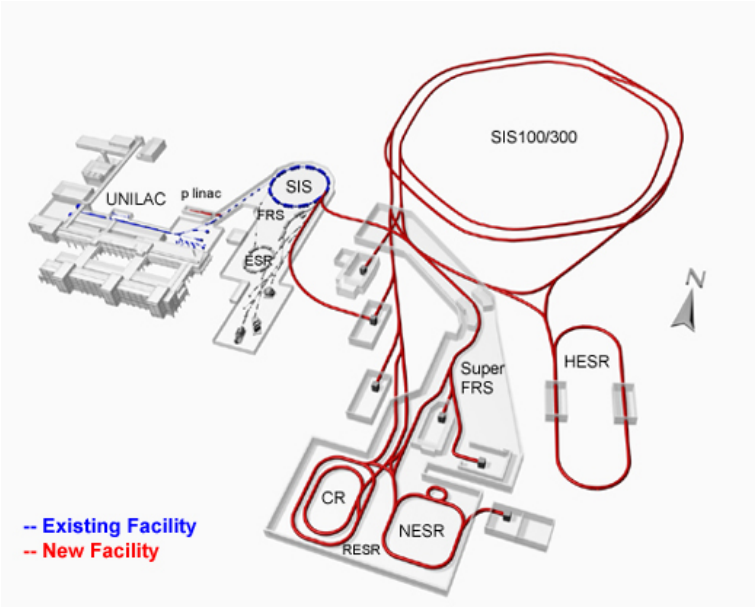
- A prototype has been fabricated by CIEMAT
- Acceptance tests have been succesfully performed
- Call for tenders after prototype approval.
- Series production



CIEMAT Contribution to the FAIR project

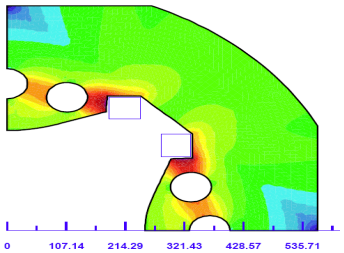
FAIR

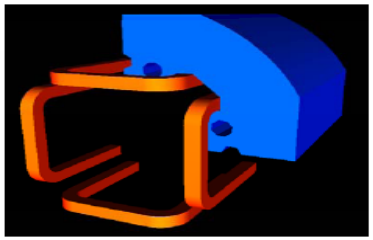
FAIR (Facility for Antiproton and Ion Research) which will be located at GSI, Darmstadt, consists of 8 circular accelerators, 2 linear accelerators and 3500 m. of beam transport.



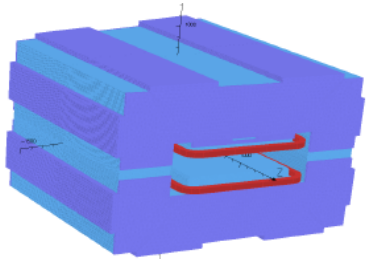
- Since 2004, CIEMAT has been collaborating in FAIR
- The final CIEMAT contribution is not well defined yet
- Two possible alternatives are:
  - ✓ Multiplets for the SFRS
  - ✓ Superferric dipoles for the SFRS

CIEMAT performed a design for the SFRS Multiplets Quadrupoles which was finally selected among other candidates.





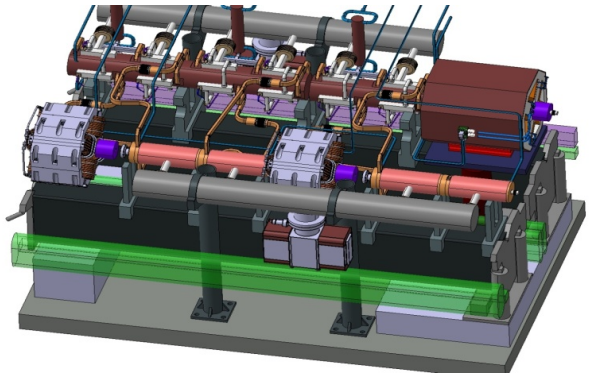
Presently, it is likely that CIEMAT contributes with the fabrication of 8 superferric superconducting dipoles for the SFRS. The first prototype has been developed in China



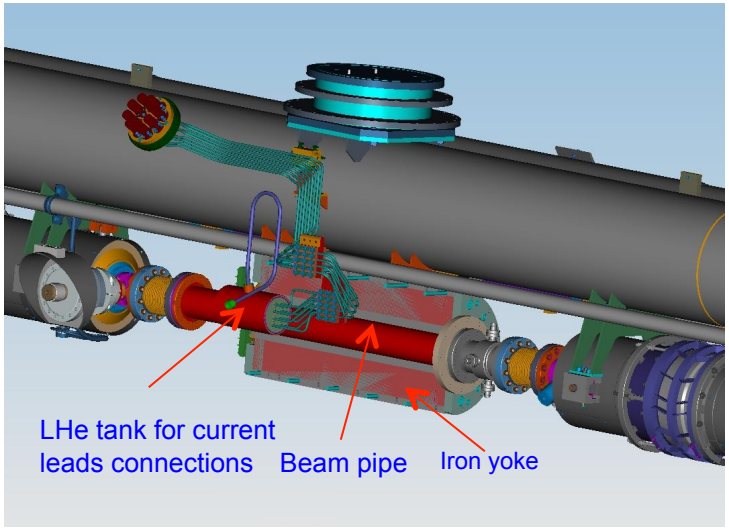
CIEMAT Contribution to the DANTE project

DANTE

CIEMAT & IFIC collaborate in the development of new technologies for future linear colliders (the DANTE project)



CLIC Module



Superconducting magnet fot ILC (courtesy of V. Kashikhin, Fermilab)

CIEMAT Tasks:

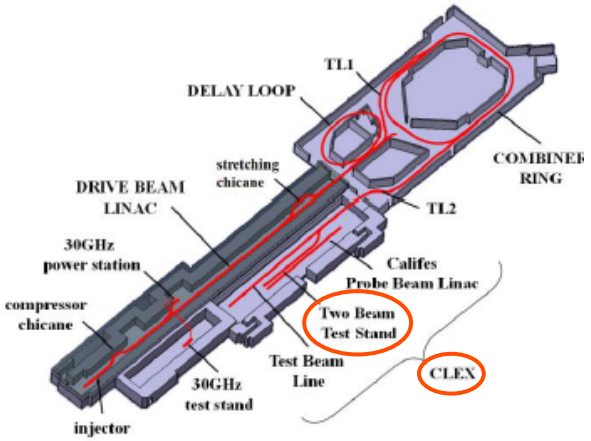
- **ILC:** Conceptual design of a superconducting magnet combined with indirect cooling
- **CLIC:** Engineering and fabrication of one prototype of PETS for the CLIC First module.
- Study of the viability of using a cyclotron for the injection in an X-band accelerator.

CLIC: PETS

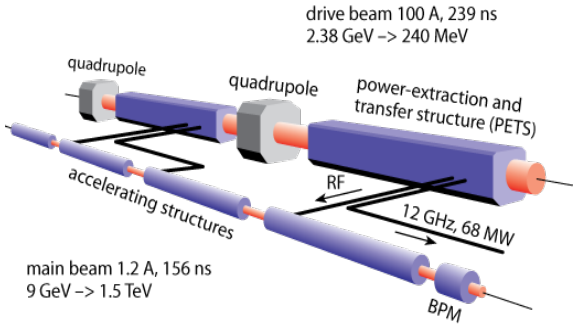
CLIC

CIEMAT collaborates with the CLIC Test Facility 3 (CTF3), which main aim is to demonstrate the feasibility of the two beam scheme of the e-e$^+$ linear collider CLIC

CIEMAT has been working in PETS for CTF3 since 2007



PETS



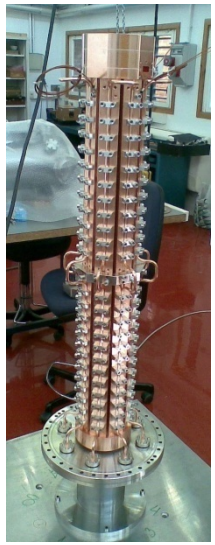
CLIC module. Source www.clic-study.web.cern.ch

- PETS (power extraction and transfer structures) are part of the accelerating modules for CLIC.
- Their function is to extract power from the drive beam and transfer it to the main beam.

- The particles interact with the corrugated structure, converting the beam energy into electromagnetic energy.
- The RF power flows through the structure and is collected at the end by a power extractor and then carried through rectangular waveguides to the accelerating structures.

CIEMAT contribution to PETS

CLIC



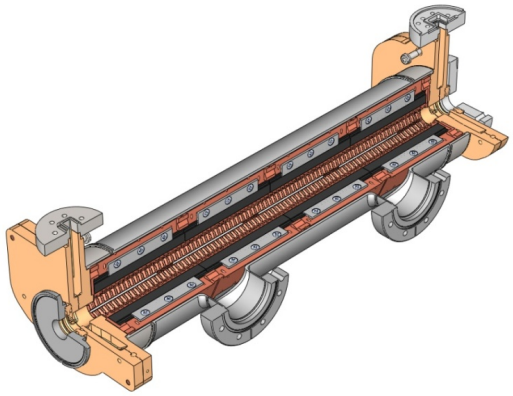
Test Beam Line in CTF3:

Study and validation of the drive beam stability during deceleration.

Scheduled 16 PETS (TBL with 12 PETS in 2012)

- First prototype:
  - Engineering design.
  - Fabrication and assembly
  - Low power RF Test.
- Series production:
  - Implementation of modifications.
  - Assembly of 3 PETS.
  - Low power RF test.
  - Fabrication of several parts for 8 tanks + 4 more tanks

CIEMAT Contribution to the Double Length CLIC PETS



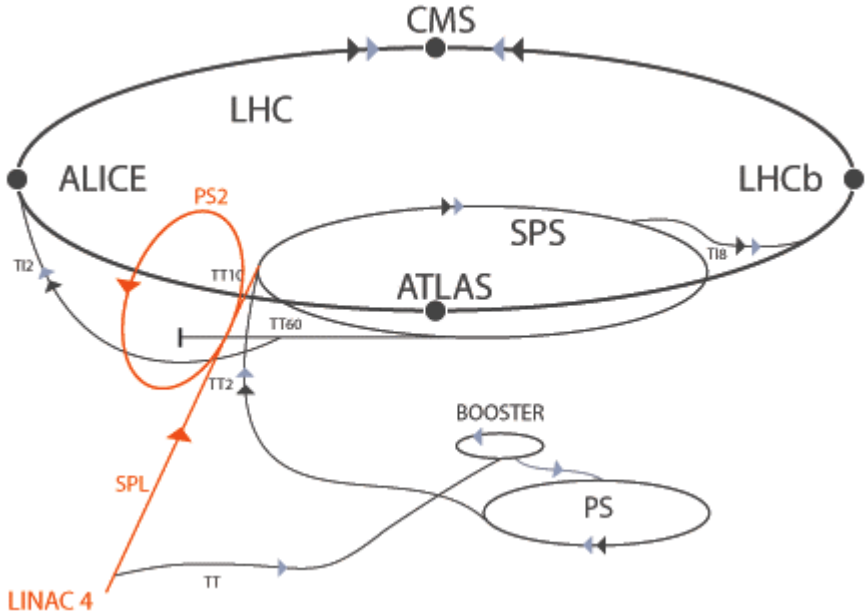
PETS designed by CERN to generate RF power in **CLEX MODULE.**

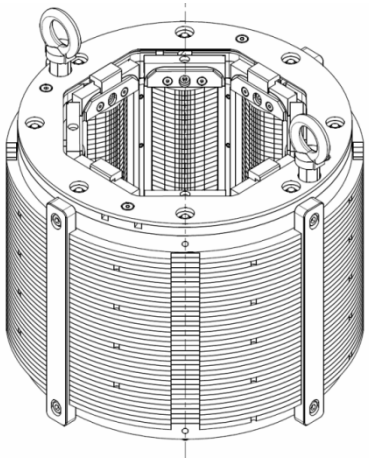
- Engineering design.
- Fabrication and assembly.
- Low power RF Tests.

CIEMAT Contribution to the SLHC-PP

SuperLHC

- CIEMAT has collaborated in the Super LHC Preparatory Phase Project (2008-2011).
- The main goal of the SLHC-PP is to increase the luminosity of the LHC.
- It is foreseen to change the magnets close to the intersection points, with higher aperture and radiation resistant magnets.
- CIEMAT is developing two superconducting corrector magnets for SLHC:
  - One **superferric sextupole**
  - One hard radiation resistance **superferric octupole**.





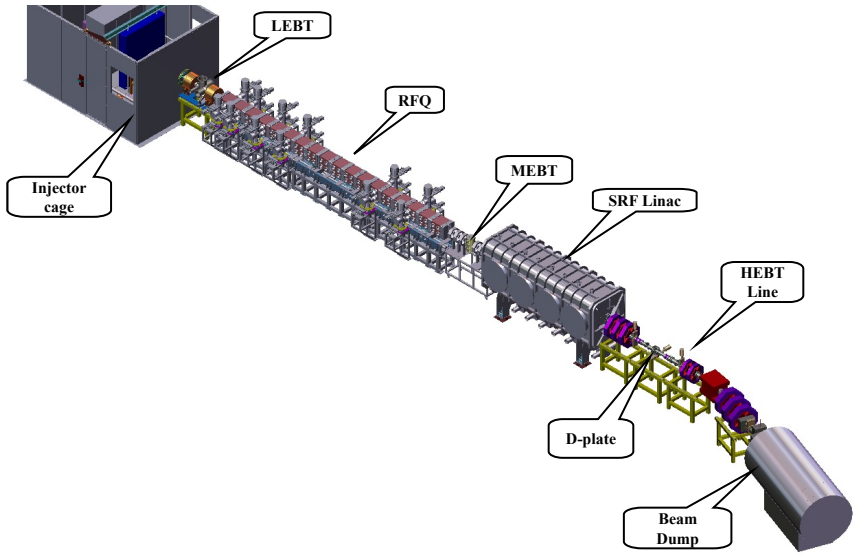
CIEMAT Contribution to the IFMIF Project

IFMIF

CIEMAT is collaborating in the International Fusion Materials Irradiation Facility (IFMIF), in the EVEDA Phase.

CIEMAT contribution to LIPAC accelerator is: 175 MHz RF systems, SRF magnet package, transport lines, 1.2 MW beam dump, beam dynamics, local control systems and beam instrumentation

Most of these packages are being developed by the Fusion group.



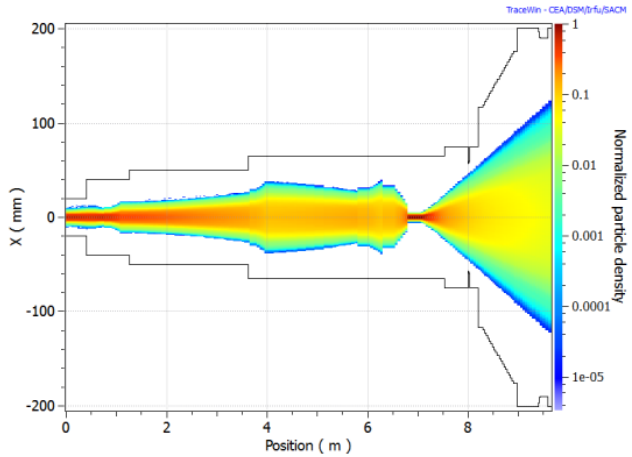
CIEMAT Contribution to the IFMIF Project

IFMIF

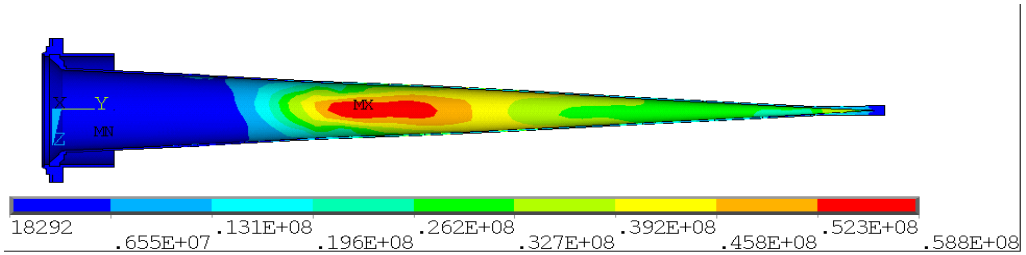
Beam diagnostics: BPMs , emittance & energy spread measurements, ...

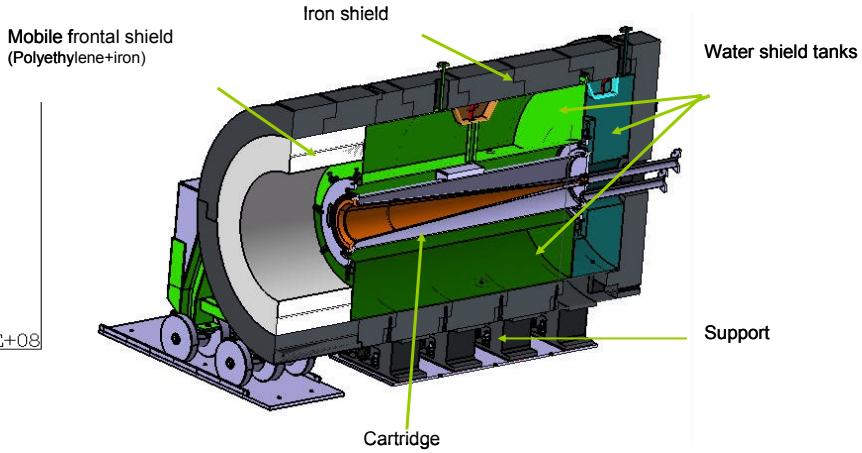
Prototype BPM

BEAM DYNAMICS



BEAM DUMP

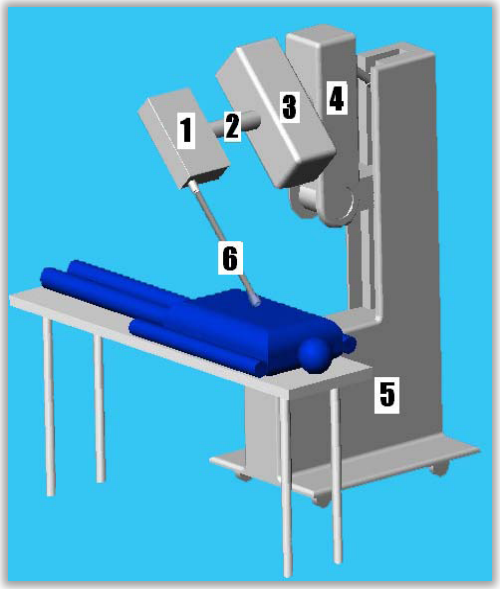


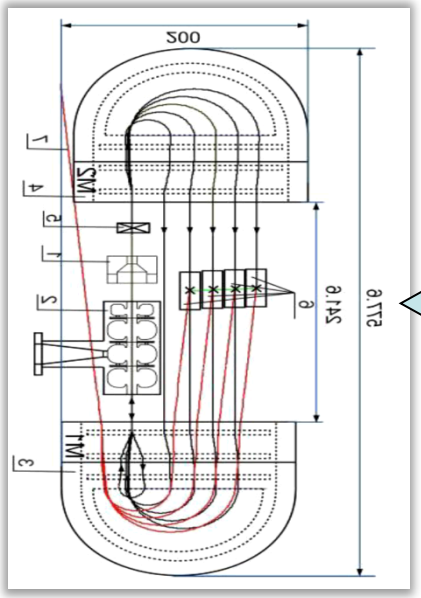


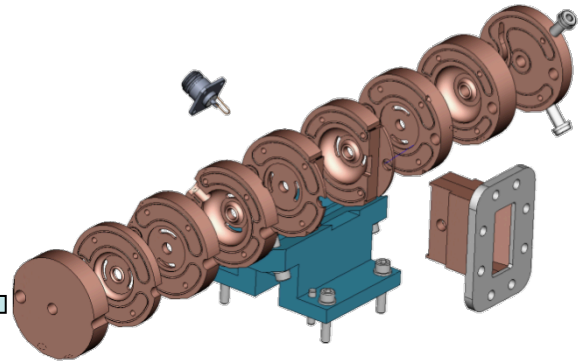
Microtron R&D Activities.

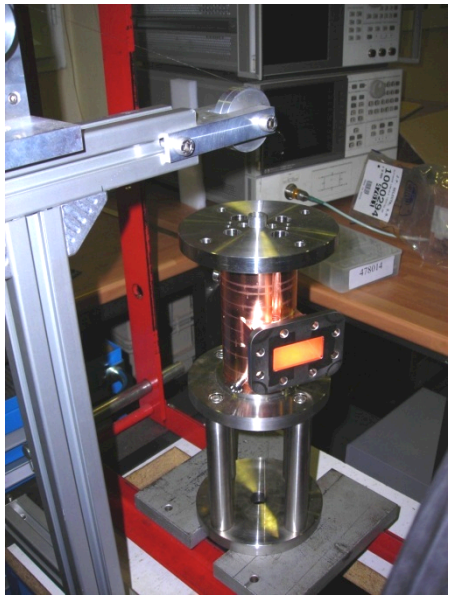
MICROTRON

A compact race-track microtron (RTM) was developed in collaboration with UPC and SINP









The CIEMAT contribution was the radiofrequency (RF) design of the 2 MeV C-Band Linac, the mechanical design and thermo mechanical calculations and to follow the machining procedure.

The LINAC was successfully finished.
The project is currently in the integration step.

The AMIT Project

AMIT

AIM OF THE **AMIT** PROJECT: Development of the core technology for molecular imaging in Medicine and Biomedicine. It is divided in 4 WP: 1) Efficient radioisotopes production 2) New techniques for radiopharmatheutical synthesis 3) New instrumentation techniques for image acquisition and 4) quantitative data processing.

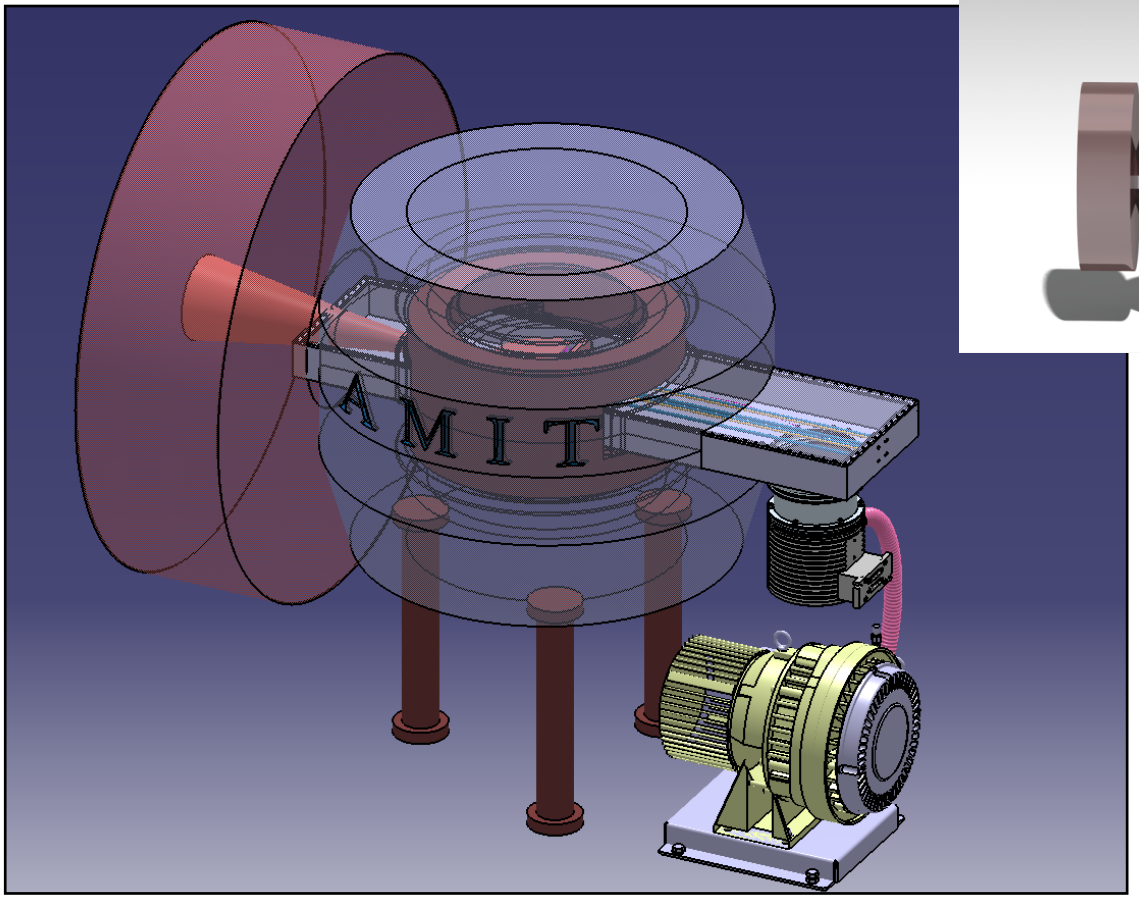
WP1: Development of a Compact Superconducting Cyclotron for ^{11}C (100mCi) and ^{18}F(40mCi) production.

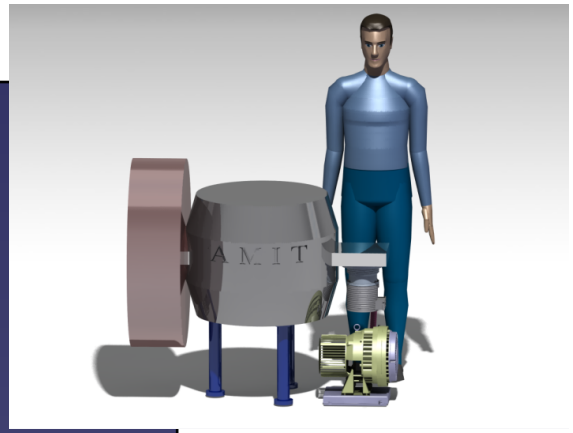
CYCLOTRON SPECIFICATIONS

PARAMETER	VALUE	UNITS
Energy	> 8.5 (1)	MeV
Current	>10 (2)	µA
Ions	H- (3)	
Magnet	Superconducting (LTc)	
Central Magnetic Field	4 (4)	T
Extraction radius	105.3	mm
Weight (exc. shielding)	< 2000	kg

Cyclotron General Layout

AMIT





The aim of the AMIT project is to develop the smallest possible cyclotron able to achieve the required energy. Presently, the proposed machine will weight around 1500 kg with an external diameter of about 800 mm.

Accelerator R&D activities: GAP at IFIC

RESEARCH ACTIVITIES

- Collimation systems studies for Circular Colliders (LHC) and Future Linear Colliders (CLIC).
- Optics studies for the Luminosity upgrade of LHC
- Optics Design and Beam Instrumentation studies for the Beam Delivery System of Future Linear Colliders (ILC and CLIC).
- Beam Dynamics studies for the EXT line of ATF-ATF2.
- Design and Construction of Beam Instrumentation:
  - Inductive Beam Position Monitors for CTF3;
  - Optical Transition Radiation Monitors for ATF-ATF2;
  - Beam Position Tunning for Hadrontherapy Facilities;
  - Stripline Kickers for CLIC Damping and Pre-Damping Rings;
- Cyclinacs for hadrontherapy applications.

COLLABORATORS

- **Doug McCormick**
- **Glen White**
- **Gabriel Montoro**
- **Fernando Toral**
- **Álvaro Lara**
- **Iván Podadera**
- **ATF2 team**
- **Yannis Papaphilippou**
- **Mike Barnes**
- **Maurice Haguenauer**
- **Patrick Poilleux**

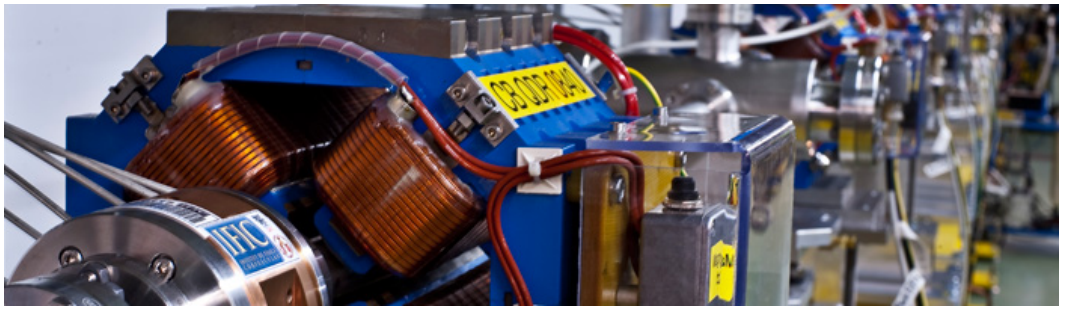
PEOPLE

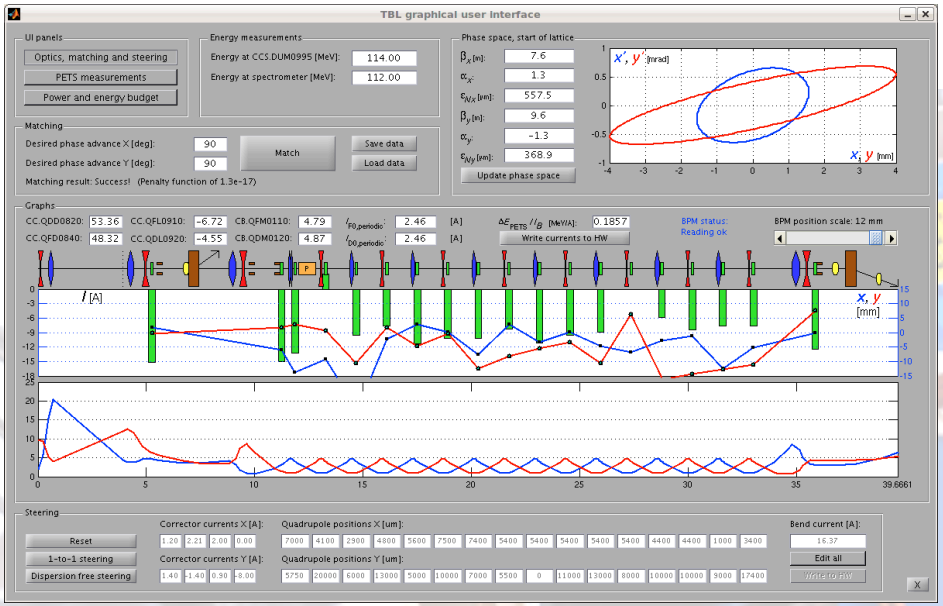
- **Dr. Angeles Faus-Golfe** (CSIC researcher)
- **Juan José García Garrigós** (Electronical engineering)
- **César Blanch Gutiérrez** (Mechanical engineering)
- **Dr. Javier Resta López** (Postdoc Juan de la Cierva)
- **Dr. Luisella Lari** (Postdoc EUCARD)
- **Silvia Verdú Andrés** (PhD PARTNER)
- **Javier Alabau Gonzalvo** (PhD Bancaja)
- **Carolina Belver Aguilar** (PhD FPI)
- **Alfonso Benot Morell (**PhD Especialización Infraestructuras Científicas y Organismos Internacionales)
- **Núria Fuster Martínez** (PhD Student UV)

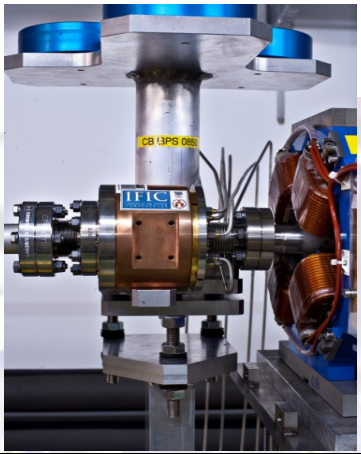
Accelerator R&D activities: GAP at IFIC

RESEARCH ACTIVITIES:
DESIGN AND CONSTRUCTION OF BEAM INSTRUMENTATION

1) Inductive Beam Position Monitors for CTF3







MEASUREMENT OF THE POSITION WITH THE BPS's IN THE TBL OF CTF3-CLIC

Accelerator R&D activities: GAP at IFIC

RESEARCH ACTIVITIES: DESIGN AND CONSTRUCTION OF BEAM INSTRUMENTATION

4) Stripline kickers for CLIC Damping and Pre-Damping Rings

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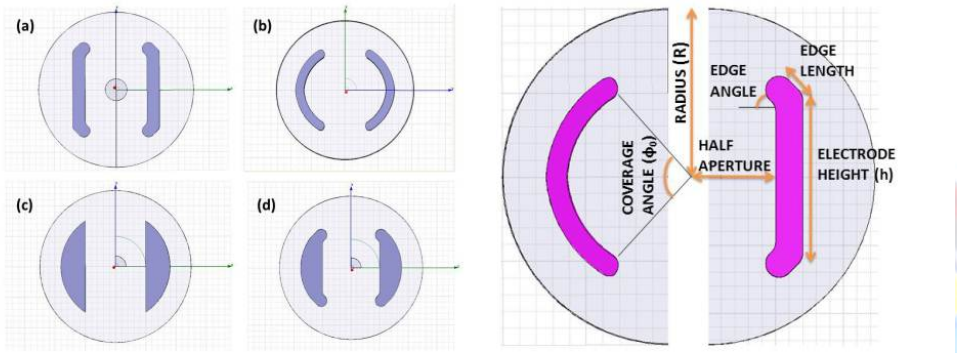
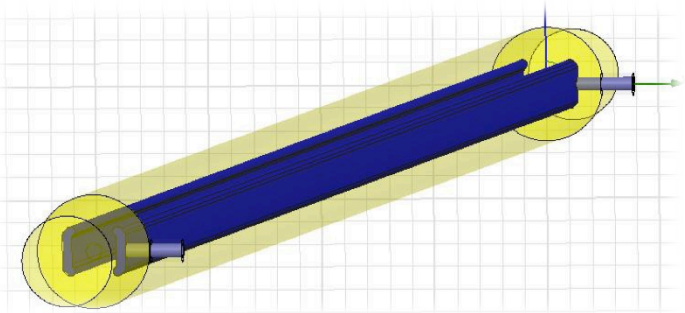
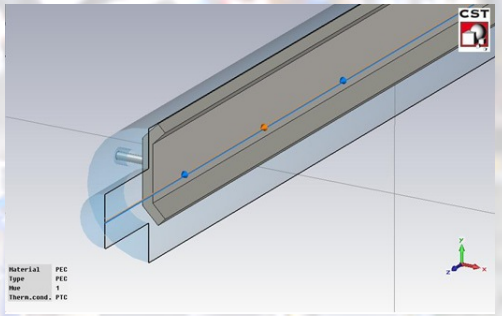
CERN

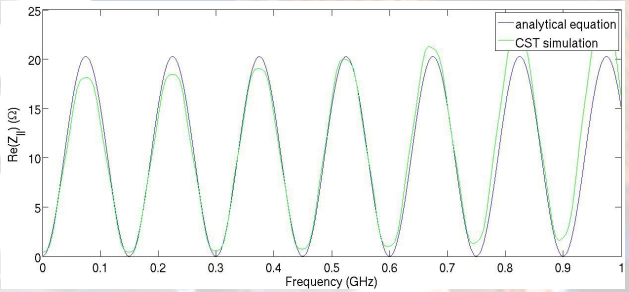
CROSS SECTION OPTIMIZATION

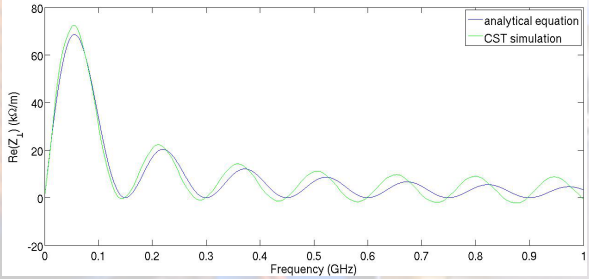




STRIPLINE ELECTRODES





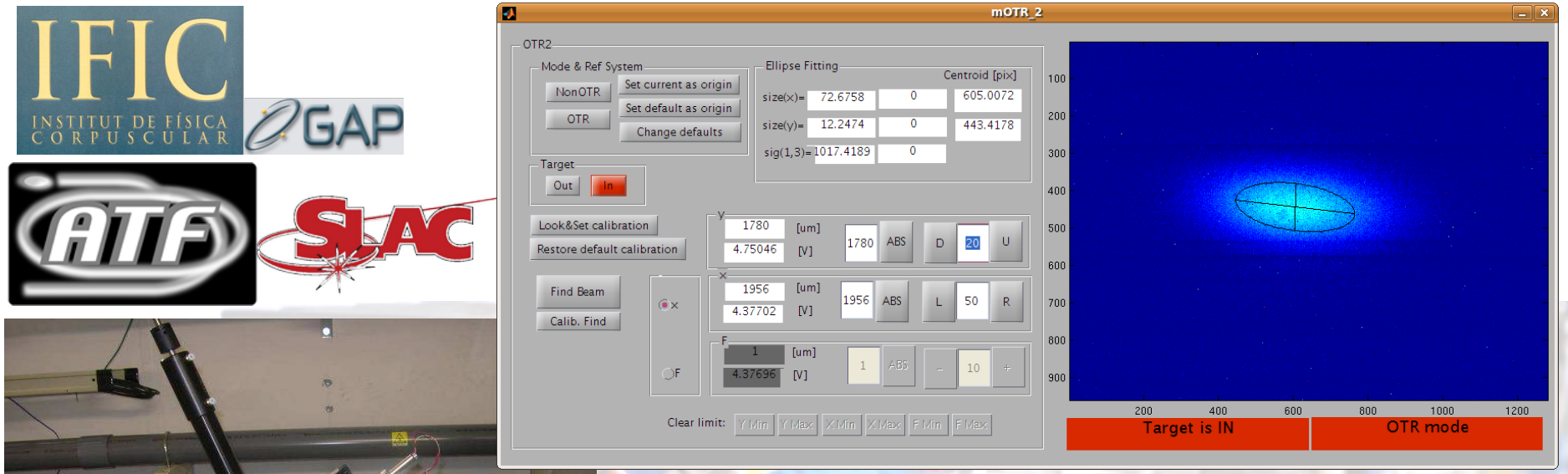


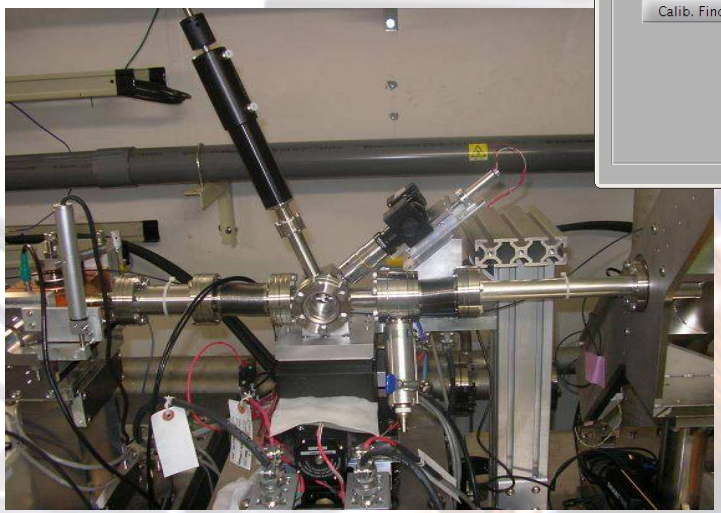
LONGITUDINAL AND TRANSVERSE BEAM COUPLING IMPEDANCE SIMULATIONS

Accelerator R&D activities: GAP at IFIC

RESEARCH ACTIVITIES:
DESIGN AND CONSTRUCTION OF BEAM INSTRUMENTATION

2) Optical Transition Radiation Monitors for ATF-ATF2





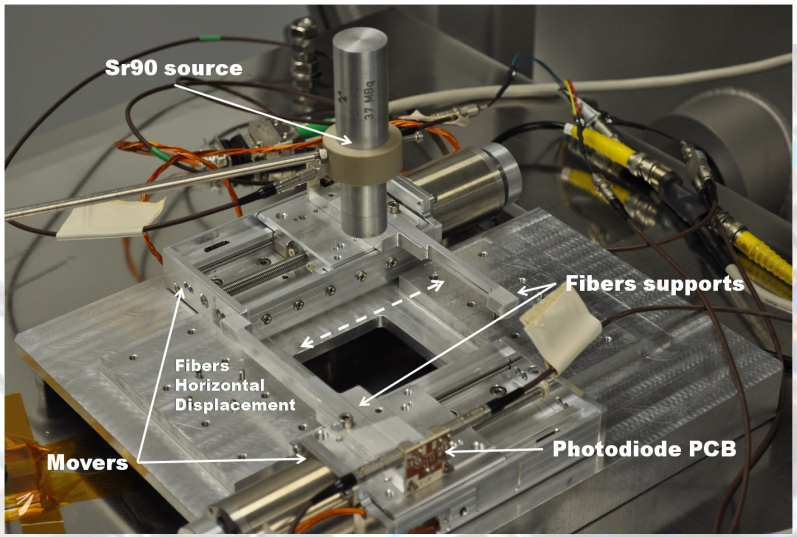
MEASUREMENT OF THE EMITTANCE AND BEAM SIZE IN ATF2 KEK WITH THE MULTIO-OTR SYSTEM

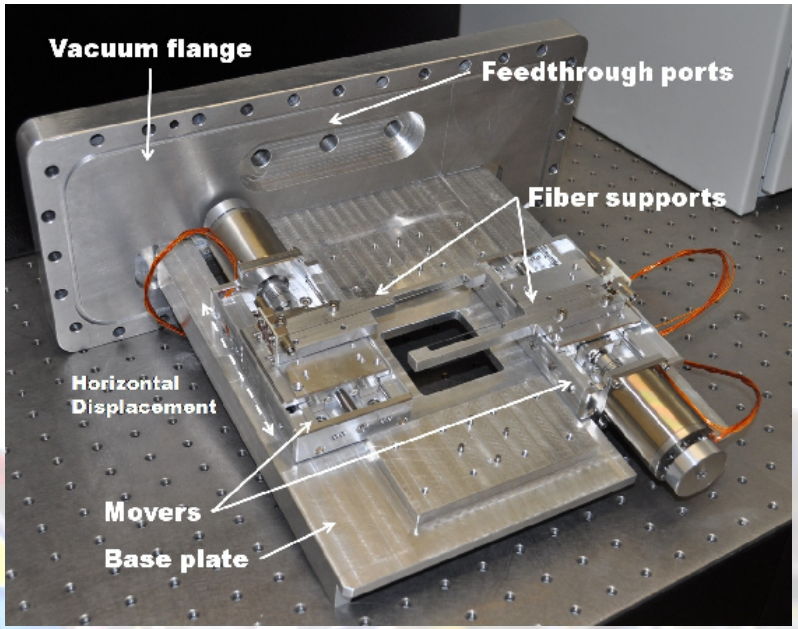
Accelerator R&D activities: GAP at IFIC

RESEARCH ACTIVITIES:
DESIGN AND CONSTRUCTION OF BEAM INSTRUMENTATION

3) Beam Position Tunning for Hadrontherapy Facilities

FIRST CALIBRATION TESTS





WATCHDOG PROTOTYPE

Summary

- **Spanish accelerator Infrastructures:**
  - **ALBA (Synchrotron Light Source, Barcelona)** a huge and successful effort which has started its exploitation.
  - **CMAM (Madrid) and CAN (Sevilla)** very useful centers providing *mainly* a national support to science (material, nuclear, etc..) and applications (radio-pharmacy, etc..).
  - **ESS-Bilbao, LRF-Huelva, IFIMED (Valencia)**, new infrastructures in construction or preparatory phase or consideration. They will have to face difficult times. Should cooperate and complement. Learn from ALBA experience as much as possible.
- **R&D activities and groups:**
  - **CIEMAT (Madrid):** a consolidated and experienced group with many international collaborations. Important contributions to many of the most advanced projects with novel accelerator techniques. The reference group in Spain for this activity.
  - **IFIC (Valencia):** a young, active and very motivated group which has interesting and visible contributions to some of the most challenging projects of the field.
  - **CIEMAT and IFIC** have an essential role for training young accelerator physicists and engineers. A good cooperation between the two groups is observed and needs to continue being supported.