R&D Spanish Activities for Future Facilities in Accelerator Particle Physics

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IFIC-Valencia

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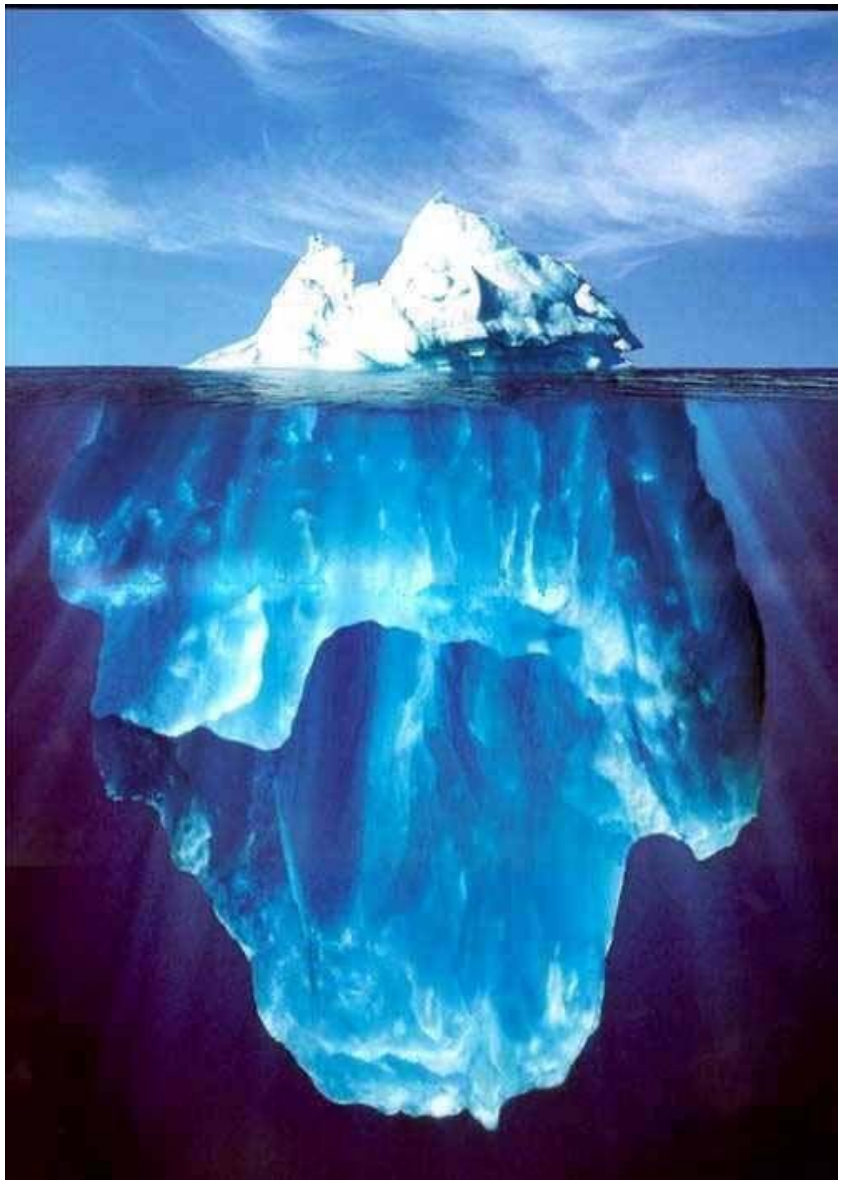
Outline

- Introduction, motivation
- Organization and Structure
- Resources
- Physics and Detector R&D activities
- Accelerator R&D activities

Outline



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  - sLHC & LHC-Upgrades
  - ILC & CLIC
  - SuperB & Belle II
- Accelerators (ILC, CLIC):
  - ATF2, CTF3
  - BPMs, BDS optics, Multi-OTR
  - PETs, Kickers, Qaudropole Movers
- Theory (ILC,CLIC, LHeC, SuperB/Belle II):
  - UGR, USC, IFIC, IFCA, IFT, IFAE, UZ, UB, UCM, etc..
- Impacts, synergies and Spin-offs

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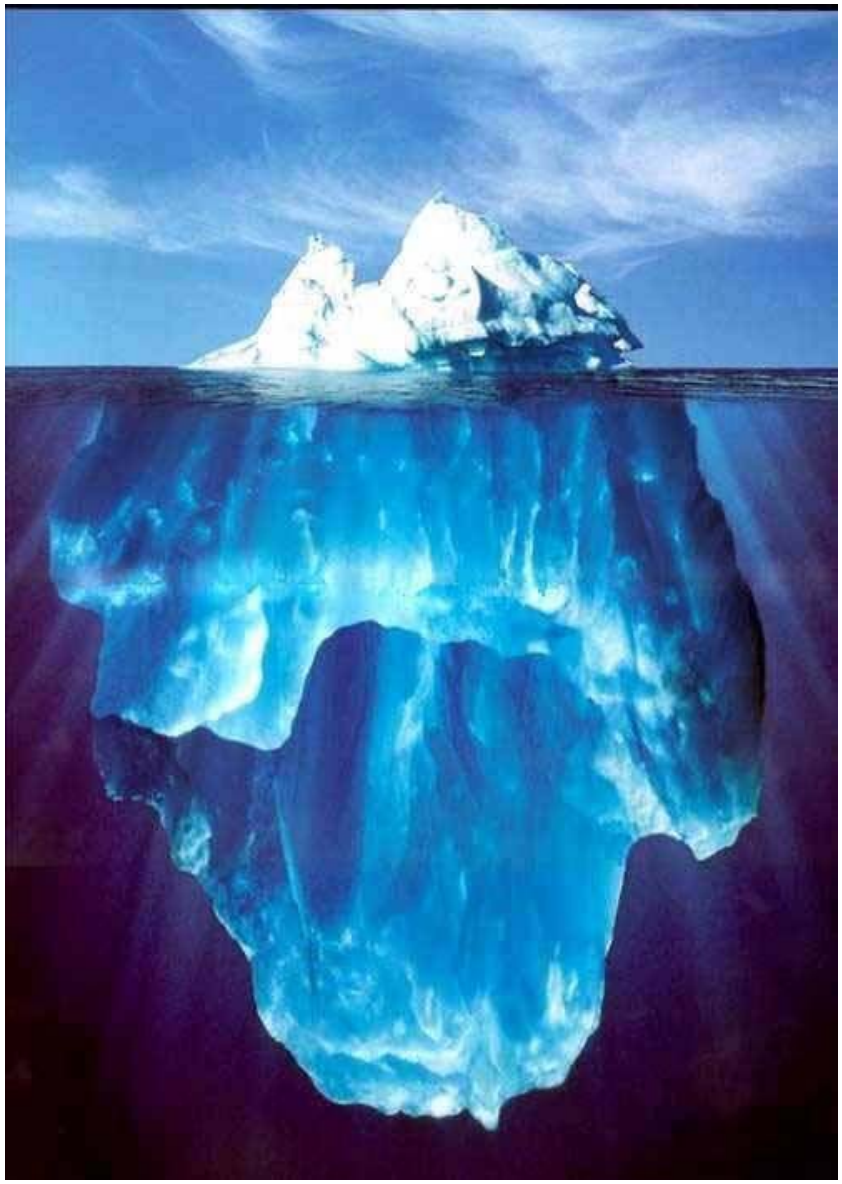

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Included in backp-up Slides

El camino hacia el LHC, 1983-2000

LEP:

LoI de experimentos 1982

Primer Workshop de la Física del LHC 1984

Aprobación de construcción del LHC por el Consejo del CERN 1994

(descubrimiento del quark top 1994)

LEP Note 440
11.4.1983

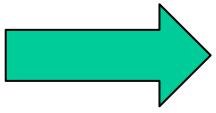
PERFORMANCE ESTIMATES FOR A LEP PROTON COLLIDER 1983

S. Myers and W. Schnell

Introduction

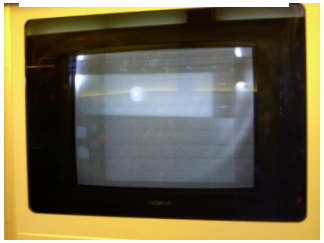
This analysis was stimulated by news from the United States where very large $p\bar{p}$ and pp colliders are actively being studied at the moment.

illustration. Thus, we shall assume throughout that the maximum energy per beam is 8 TeV (corresponding to a little over 9 T bending field in very advanced superconducting magnets) and that injection is at 0.4 TeV. The ring circumference is, of course that of LEP, namely 26,659 m. It should be clear from this requirement of "Ten Tesla Magnets" alone that such a project is not for the near future and that it should not be attempted before the technology is ready.

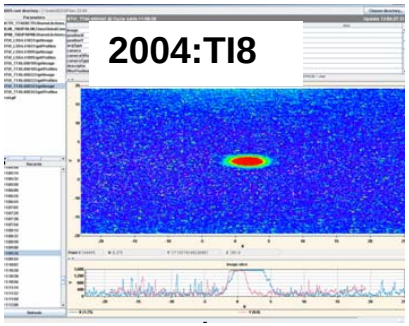


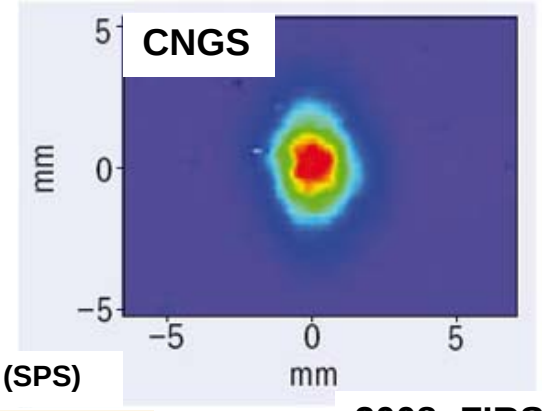
El camino hacia el LHC, 2000-2009

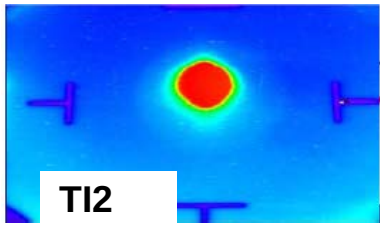
2003:TT40



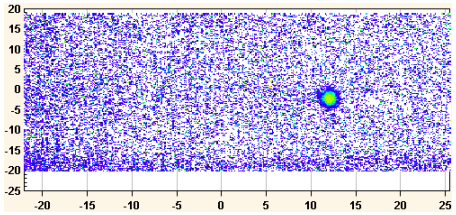
2004:TI8



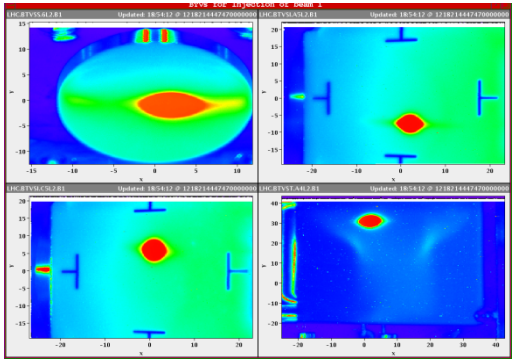




2005: FIRST HOLE (SPS)

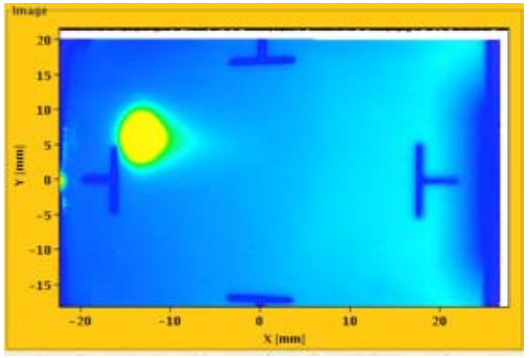


2008: FIRST BEAM TO LHC

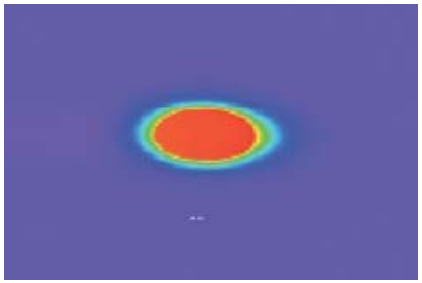


2008: 19-Sep-2008

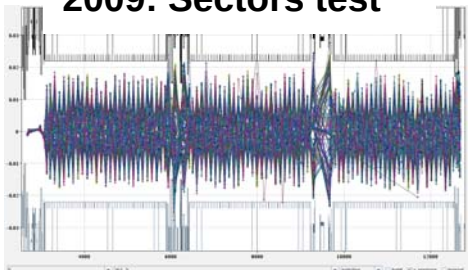
2008: FIRST BEAM TO IR3

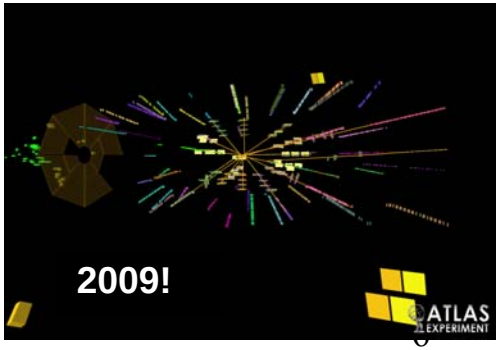


2009: FIRST IONS TO LHC

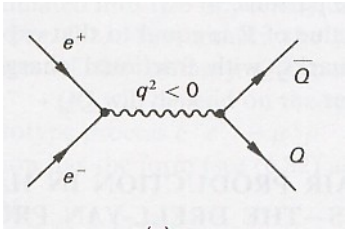


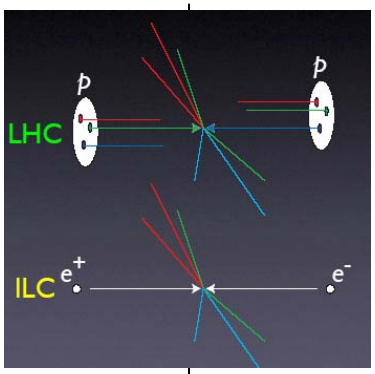
2009: Sectors test

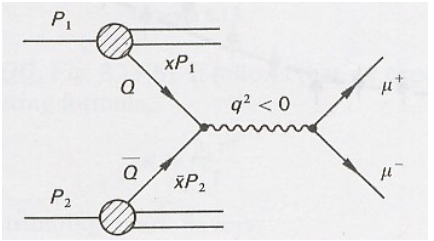


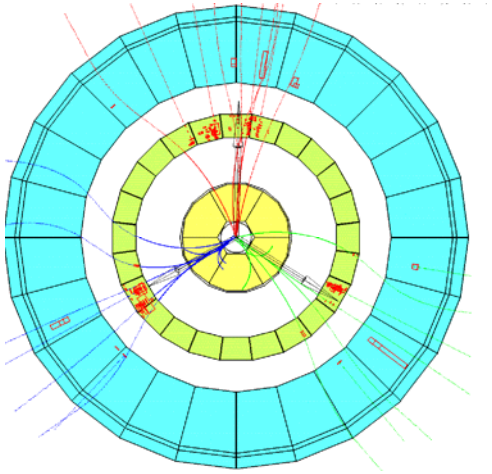


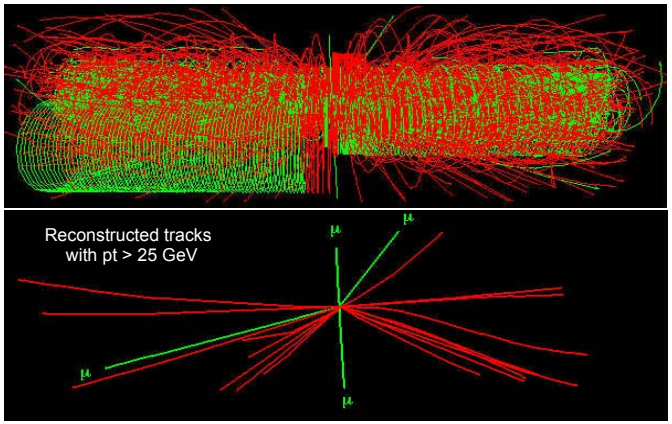
Aceleradores: e^+e^- versus $p\bar{p}$/pp











Los haces son de partículas elementales (e^+e^-)

- **Energía de la interacción conocida**
- **Todo el estado final es producto de la interacción**
- **Especialidad:**
  - **Física de Precisión + Alta energía**
  - **Descubrimientos y alta precisión**

Los haces son partículas compuestas (pp)

- **Energía de la interacción desconocida**
- **Solo parte del estado final es producto de la interacción**
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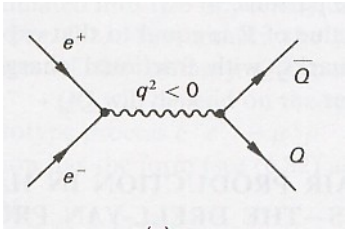
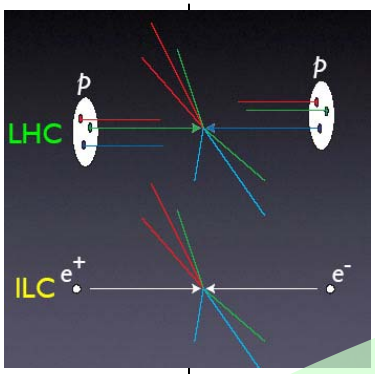
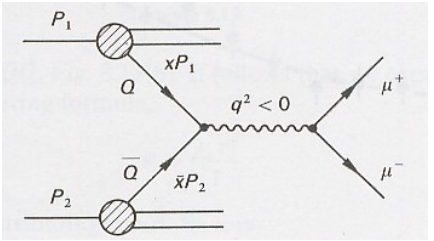
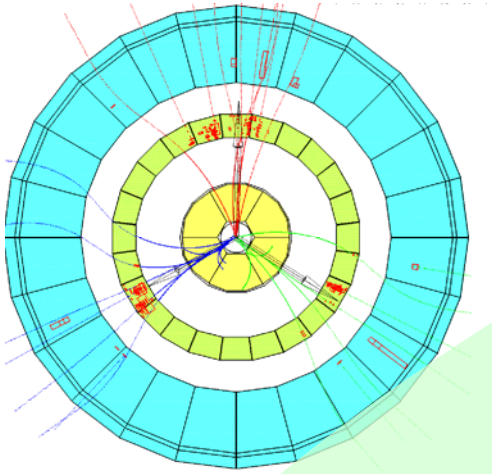
  - **Exploración de regiones cinemáticas nuevas, descubrimientos.**

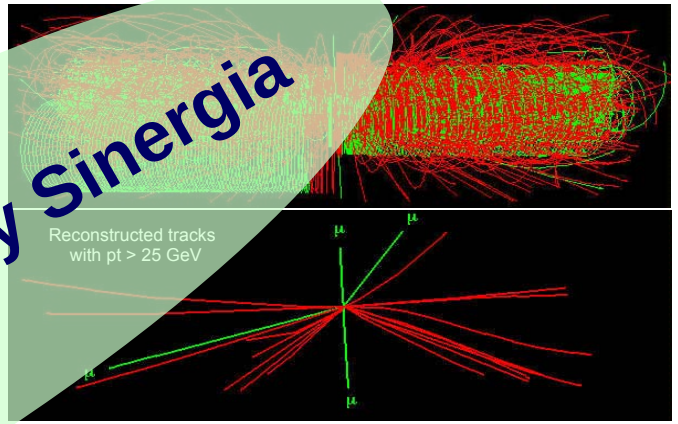
Aceleradores: e^+e^- versus $p\bar{p}$/pp











Gran Complementariedad y Sinergia

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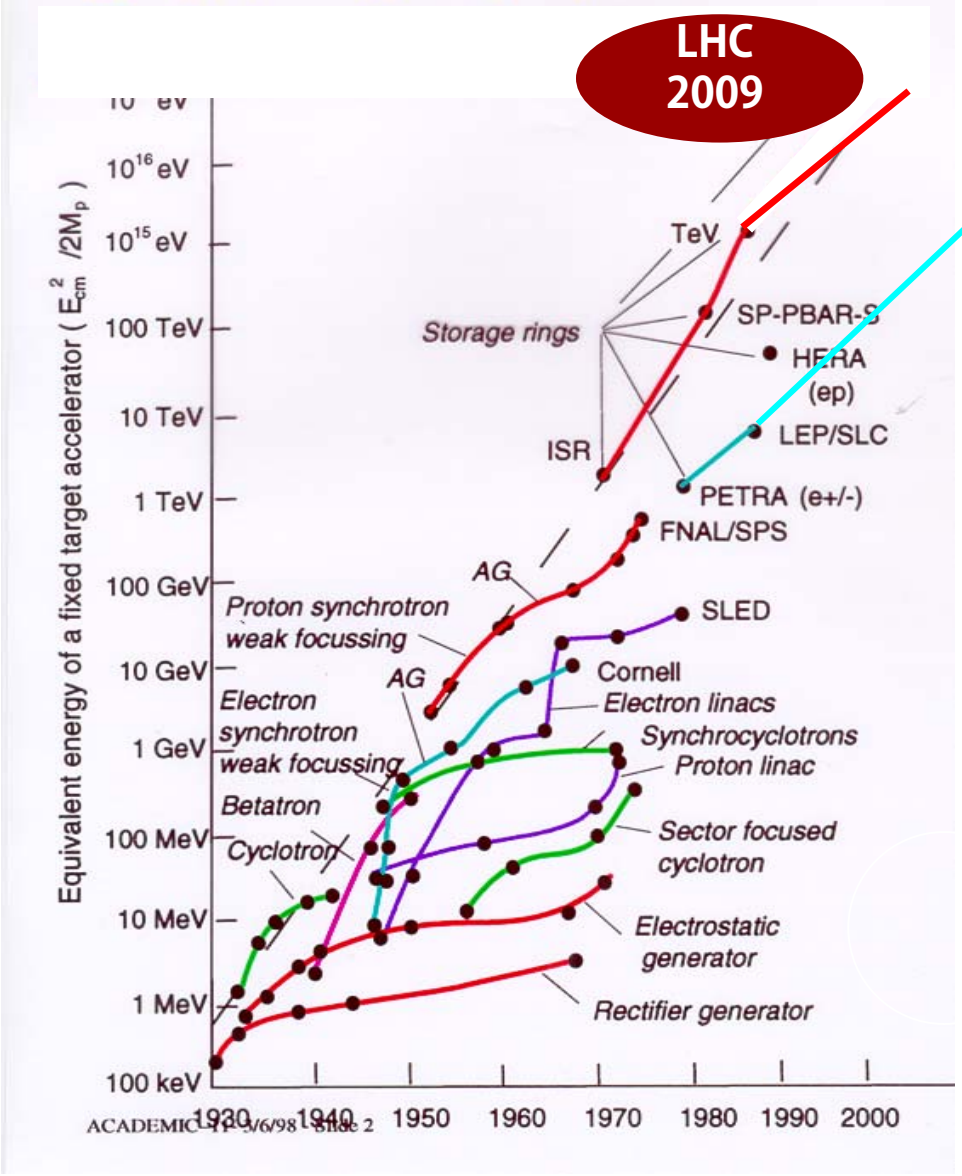
Aceleradores: Histórico



- Desarrollo Exponencial, sostenido durante los últimos 80 años
- El progreso se ha realizado alternando periodos de saturación e invención de nuevas tecnologías
- Superconductividad, es la tecnología clave para las Altas Energías desde 1980

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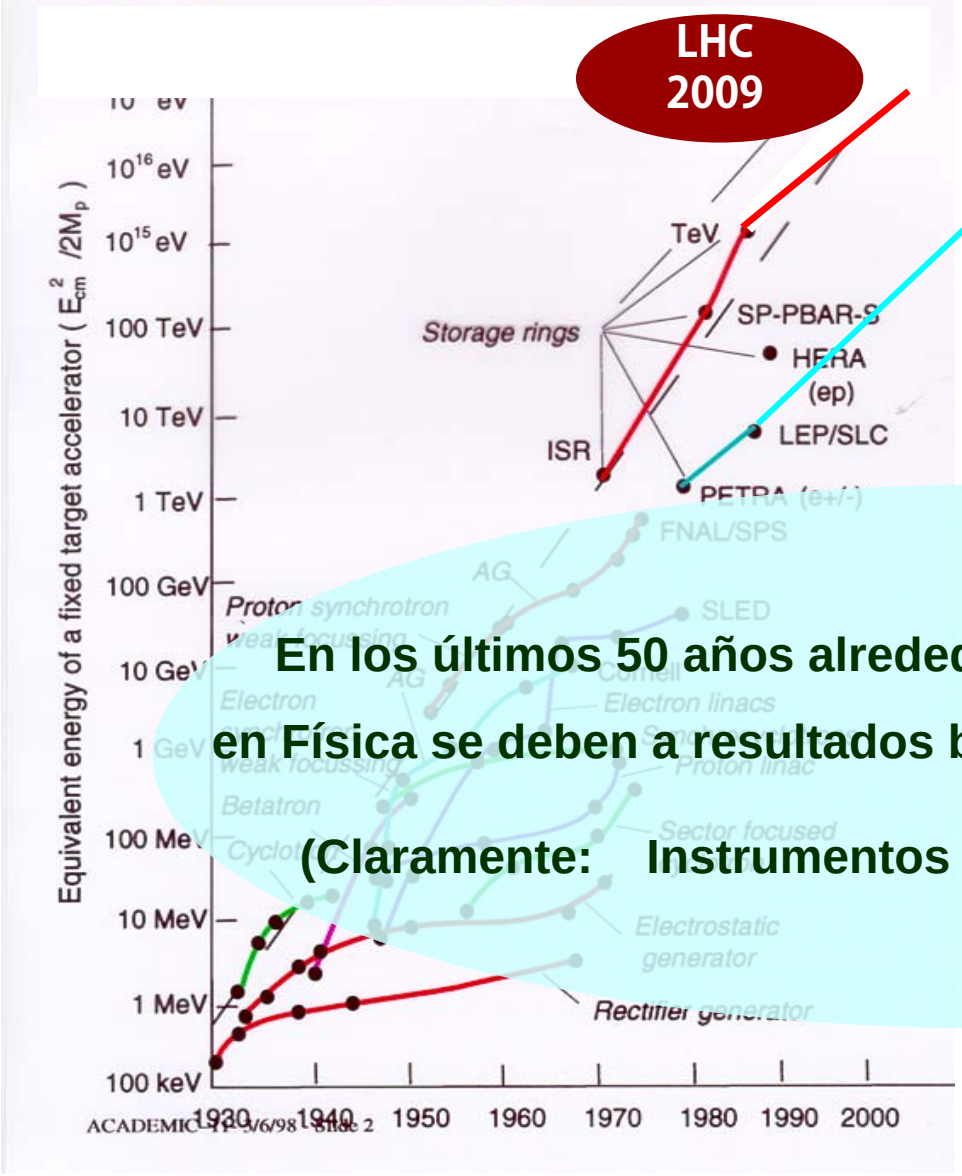

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En los últimos 50 años alrededor de 1/3 de los Premios Nobeles en Física se deben a resultados basados u obtenidos en aceleradores

(Claramente: Instrumentos muy útiles para la investigación)

24 Nobel Prizes in Physics that had direct contribution from accelerators

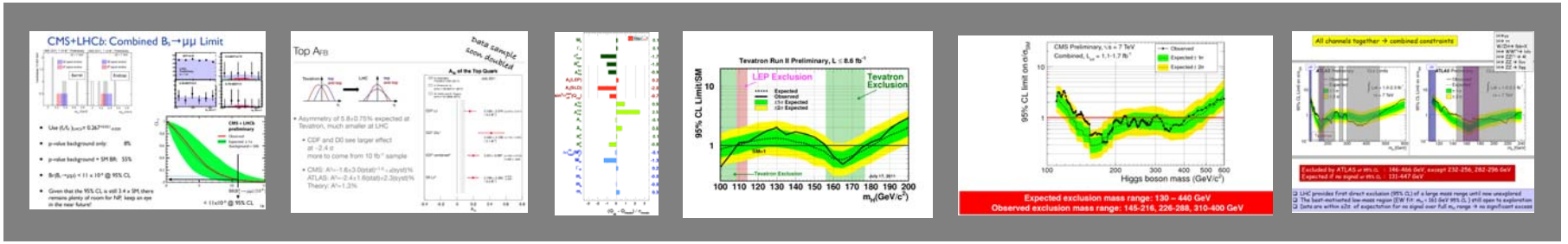
Year	Name	Accelerator-Science Contribution to Nobel Prize-Winning Research
1939	Ernest O. Lawrence	Lawrence invented the cyclotron at the University of Californian at Berkeley in 1929 [12].
1951	John D. Cockcroft and Ernest T.S. Walton	Cockcroft and Walton invented their eponymous linear positive-ion accelerator at the Cavendish Laboratory in Cambridge, England, in 1932 [13].
1952	Felix Bloch	Bloch used a cyclotron at the Crocker Radiation Laboratory at the University of California at Berkeley in his discovery of the magnetic moment of the neutron in 1940 [14].
1957	Tsung-Dao Lee and Chen Ning Yang	Lee and Yang analyzed data on K mesons (θ and τ) from Bevatron experiments at the Lawrence Radiation Laboratory in 1955 [15], which supported their idea in 1956 that parity is not conserved in weak interactions [16].
1959	Emilio G. Segrè and Owen Chamberlain	Segrè and Chamberlain discovered the antiproton in 1955 using the Bevatron at the Lawrence Radiation Laboratory [17].
1960	Donald A. Glaser	Glaser tested his first experimental six-inch bubble chamber in 1955 with high-energy protons produced by the Brookhaven Cosmotron [18].
1961	Robert Hofstadter	Hofstadter carried out electron-scattering experiments on carbon-12 and oxygen-16 in 1959 using the SLAC linac and thereby made discoveries on the structure of nucleons [19].
1963	Maria Goeppert Mayer	Goeppert Mayer analyzed experiments using neutron beams produced by the University of Chicago cyclotron in 1947 to measure the nuclear binding energies of krypton and xenon [20], which led to her discoveries on high magic numbers in 1948 [21].
1967	Hans A. Bethe	Bethe analyzed nuclear reactions involving accelerated protons and other nuclei whereby he discovered in 1939 how energy is produced in stars [22].
1968	Luis W. Alvarez	Alvarez discovered a large number of resonance states using his fifteen-inch hydrogen bubble chamber and high-energy proton beams from the Bevatron at the Lawrence Radiation Laboratory [23].
1976	Burton Richter and Samuel C.C. Ting	Richter discovered the J/Ψ particle in 1974 using the SPEAR collider at Stanford [24], and Ting discovered the J/Ψ particle independently in 1974 using the Brookhaven Alternating Gradient Synchrotron [25].
1979	Sheldon L. Glashow, Abdus Salam, and Steven Weinberg	Glashow, Salam, and Weinberg cited experiments on the bombardment of nuclei with neutrinos at CERN in 1973 [26] as confirmation of their prediction of weak neutral currents [27].
1980	James W. Cronin and Val L. Fitch	Cronin and Fitch concluded in 1964 that CP (charge-parity) symmetry is violated in the decay of neutral K mesons based upon their experiments using the Brookhaven Alternating Gradient Synchrotron [28].
1981	Kai M. Siegbahn	Siegbahn invented a weak-focusing principle for betatrons in 1944 with which he made significant improvements in high-resolution electron spectroscopy [29].
1983	William A. Fowler	Fowler collaborated on and analyzed accelerator-based experiments in 1958 [30], which he used to support his hypothesis on stellar-fusion processes in 1957 [31].
1984	Carlo Rubbia and Simon van der Meer	Rubbia led a team of physicists who observed the intermediate vector bosons W and Z in 1983 using CERN's proton-antiproton collider [32], and van der Meer developed much of the instrumentation needed for these experiments [33].
1986	Ernst Ruska	Ruska built the first electron microscope in 1933 based upon a magnetic optical system that provided large magnification [34].
1988	Leon M. Lederman, Melvin Schwartz, and Jack Steinberger	Lederman, Schwartz, and Steinberger discovered the muon neutrino in 1962 using Brookhaven's Alternating Gradient Synchrotron [35].
1989	Wolfgang Paul	Paul's idea in the early 1950s of building ion traps grew out of accelerator physics [36].
1990	Jerome I. Friedman, Henry W. Kendall, and Richard E. Taylor	Friedman, Kendall, and Taylor's experiments in 1974 on deep inelastic scattering of electrons on protons and bound neutrons used the SLAC linac [37].
1992	Georges Charpak	Charpak's development of multiwire proportional chambers in 1970 were made possible by accelerator-based testing at CERN [38].
1995	Martin L. Perl	Perl discovered the tau lepton in 1975 using Stanford's SPEAR collider [39].
2004	David J. Gross, Frank Wilczek, and H. David Politzer	Gross, Wilczek, and Politzer discovered asymptotic freedom in the theory of strong interactions in 1973 based upon results from the SLAC linac on electron-proton scattering [40].
2008	Makoto Kobayashi and Toshihide Maskawa	Kobayashi and Maskawa's theory of quark mixing in 1973 was confirmed by results from the KEKB accelerator at KEK (High Energy Accelerator Research Organization) in Tsukuba, Ibaraki Prefecture, Japan, and the PEP II (Positron Electron Project II) at SLAC [41], which showed that quark mixing in the six-quark model is the dominant source of broken symmetry [42].

W. Chou, ICFA Meeting, Beijing Februray 2011

Present motivation and situation

LHC is a unique machine which is presently:

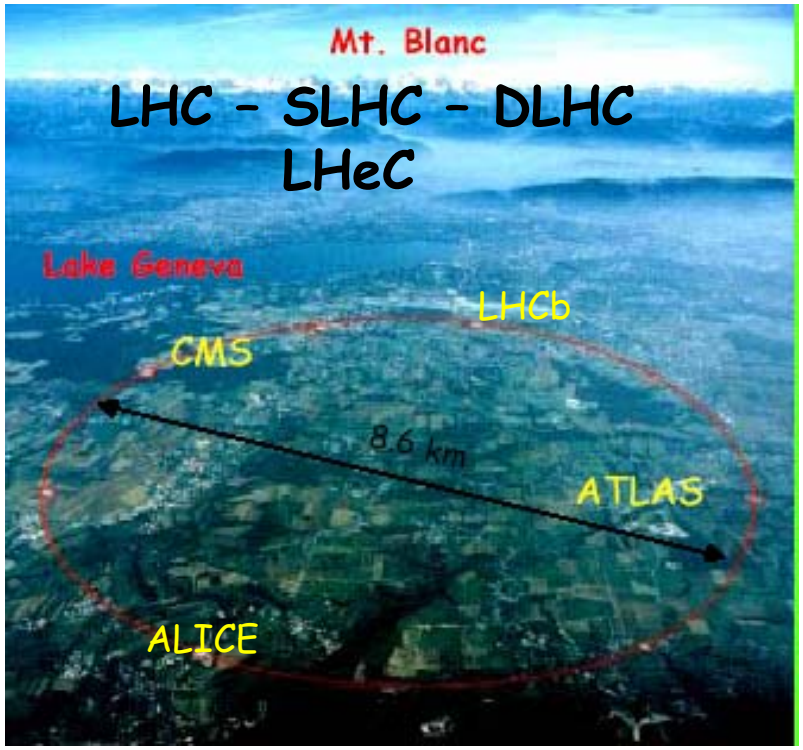
- Exploring the physics at 10^{-17}cm $\Leftrightarrow$ TeV^{-1}, ie, the weak scale (High Energy Frontier, ATLAS and CMS)
- Testing Flavour Physics (High Intensity Frontier, LHCb + ATLAS + CMS)
- Testing Hadronic Physics (ALICE+CMS+ATLAS)



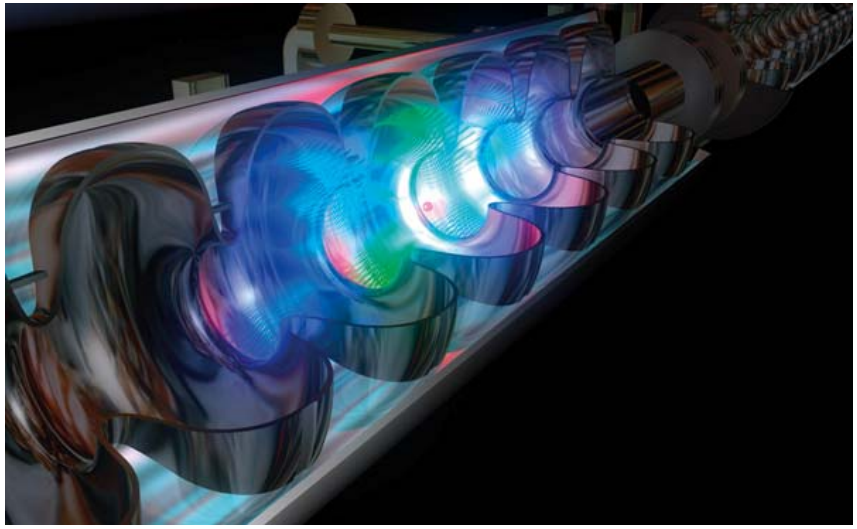
Exciting results await to come, among them, by the end of 2012 it appears possible either to find the Standard Model Higgs or to exclude it.

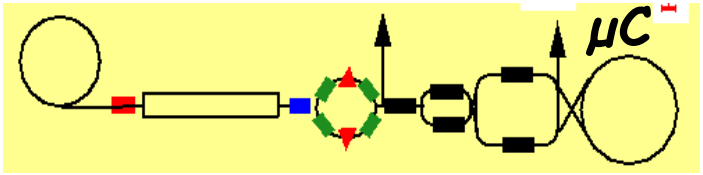
Importat implications for future work, R&D and future facilities

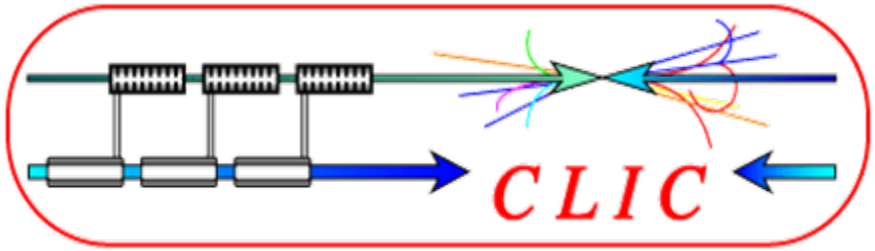
Future Facilities: High Energy and High Intensity Frontiers

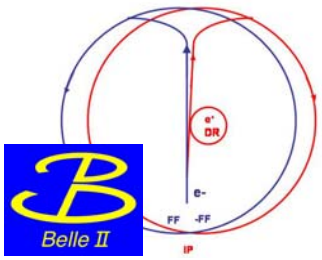


ILC International Linear Collider

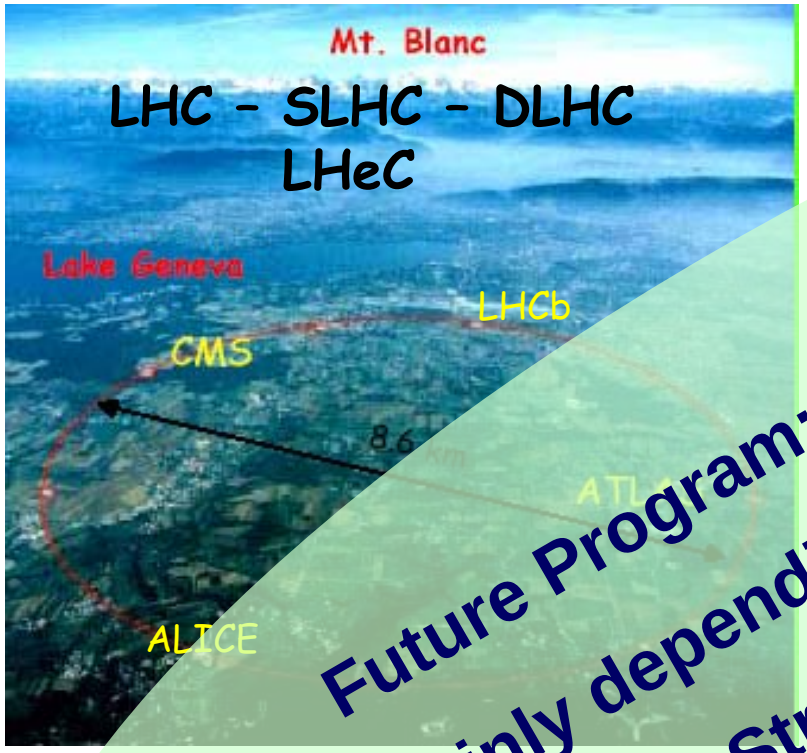




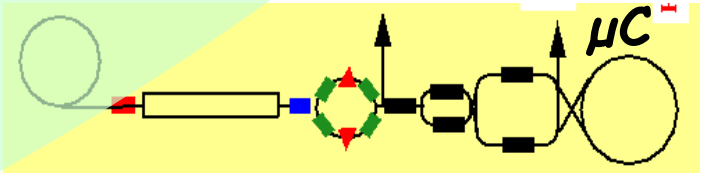


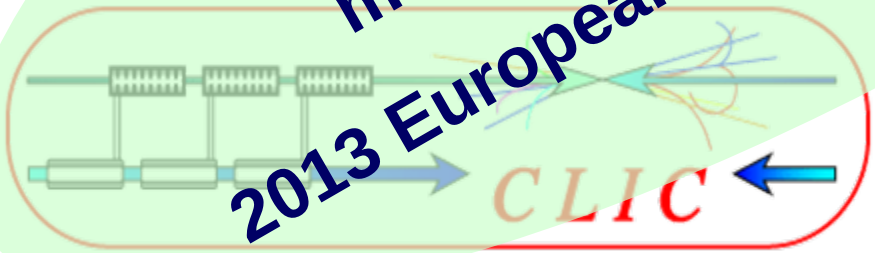


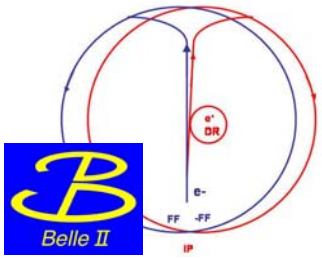
Future Facilities: High Energy and High Intensity Frontiers



Future Program: Physics Driven,
mainly depending on LHC results,
2013 European Strategy, Important Decisions







Challenges for Future Colliders

sLHC-Upgrades	→	radiation, *pileup*, high backgrounds high luminosity
FLC=ILC/CLIC	→	high precision, hermeticity, particle-flow, nano-beams, very high luminosity
Super B Factories	→	radiation, background, particle-ID, very high luminosity,nano-beams

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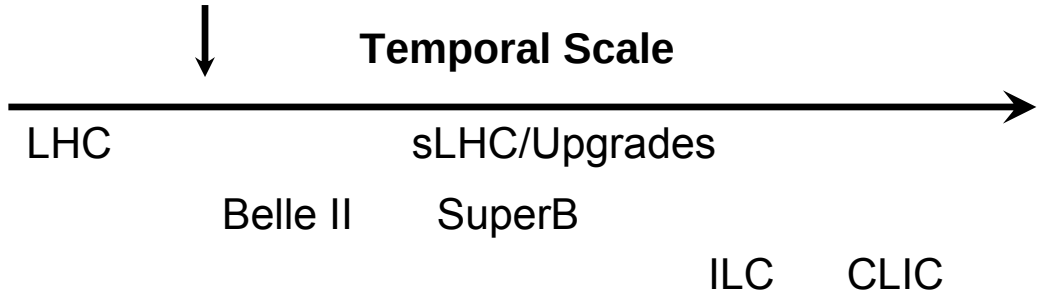
2013: Decision for European Strategy



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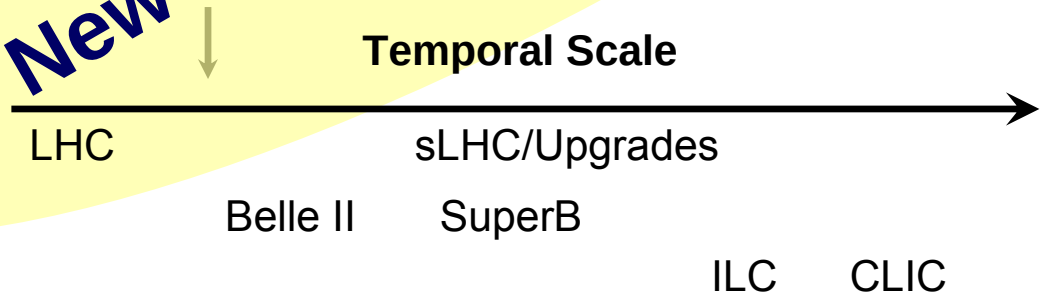
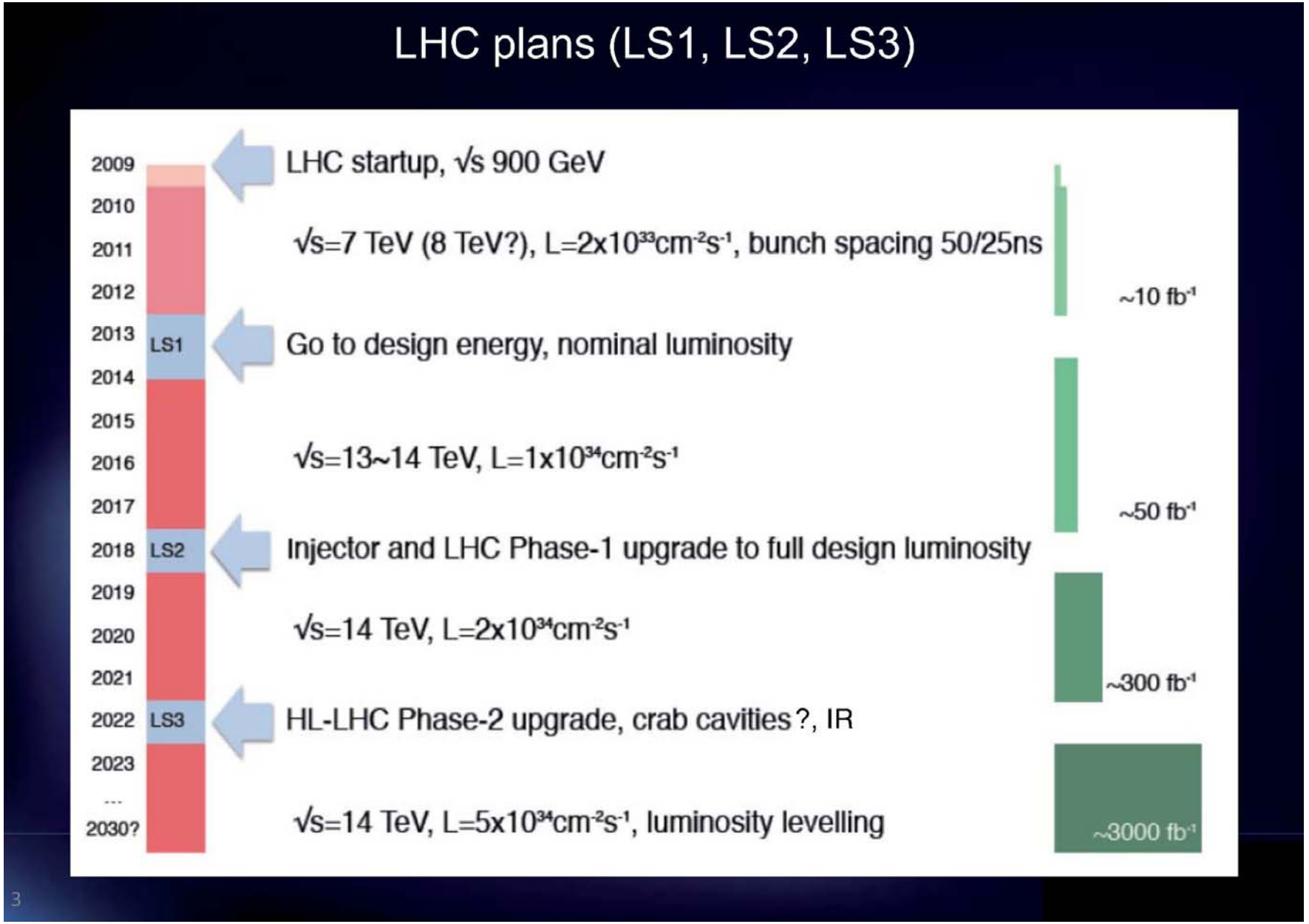
R&D Phase is needed to develop New Detectors and Accelerators

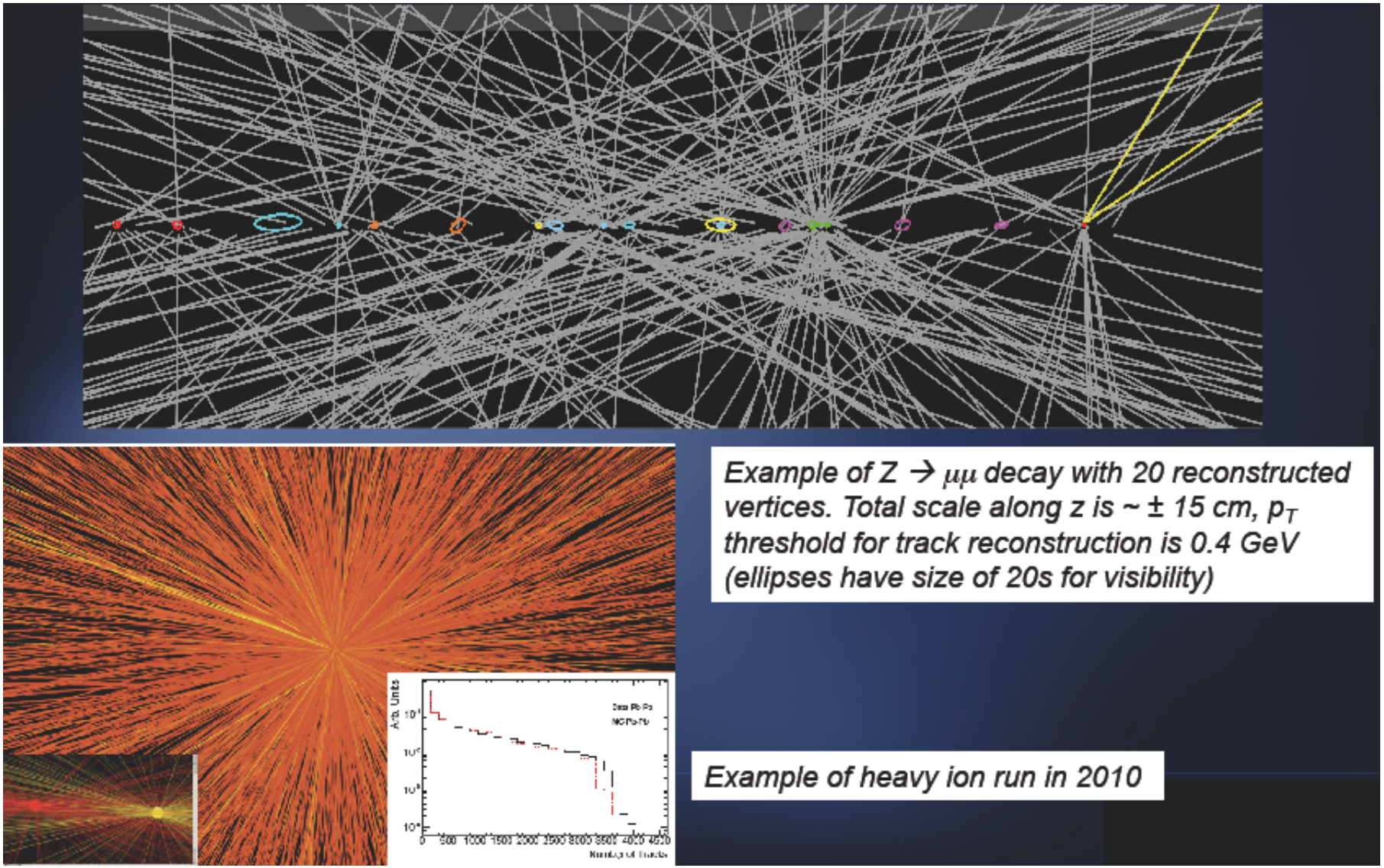
2013: Decision for European Strategy



Present Plans for LHC



sLHC challenges pile-up

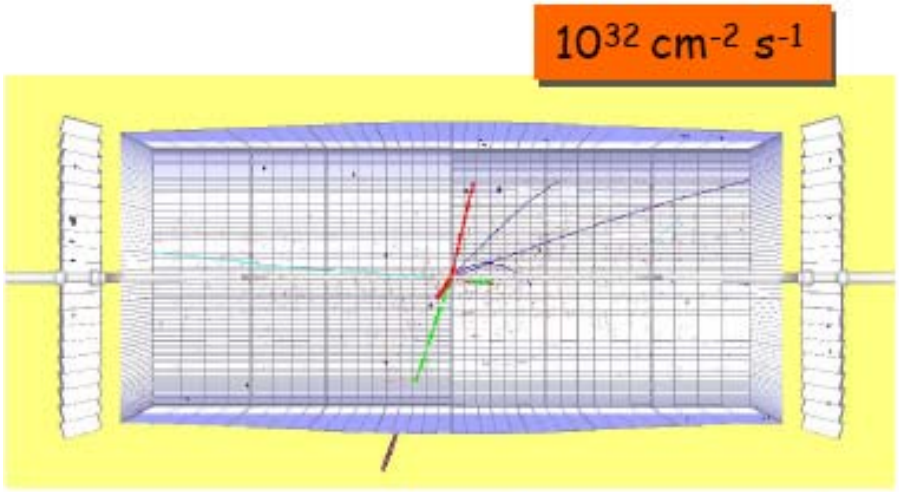


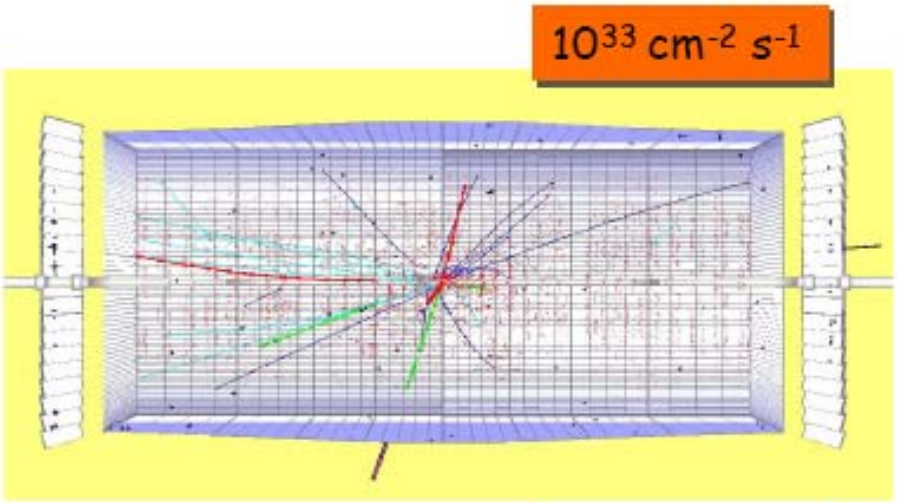
Example of Z → μμ decay with 20 reconstructed vertices. Total scale along z is ~ ± 15 cm, p_T threshold for track reconstruction is 0.4 GeV (ellipses have size of 20s for visibility)

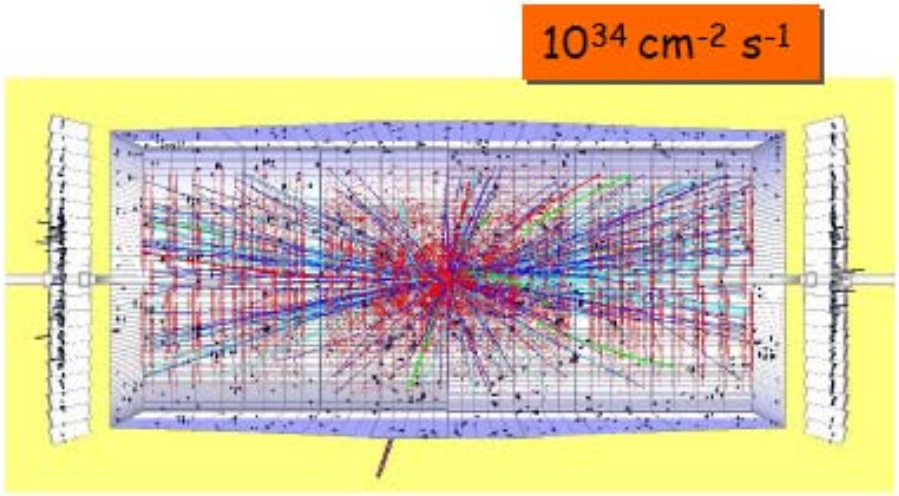
Example of heavy ion run in 2010

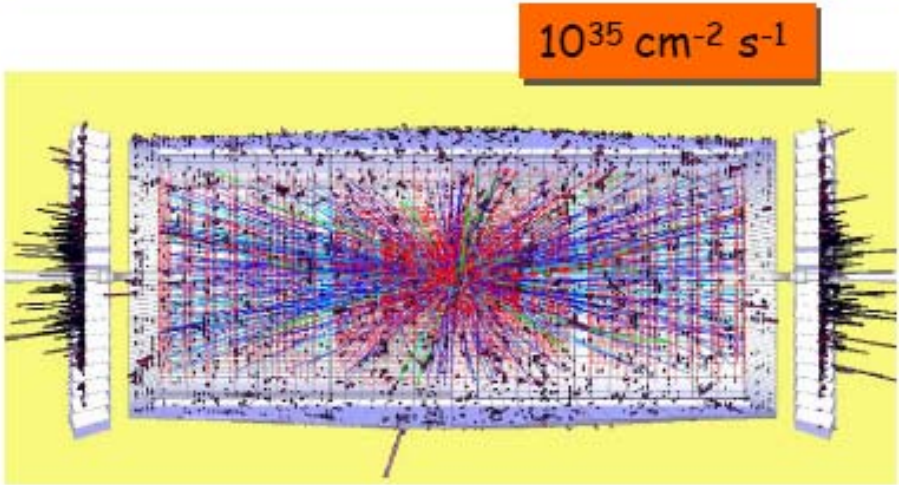
sLHC

Visualización del reto

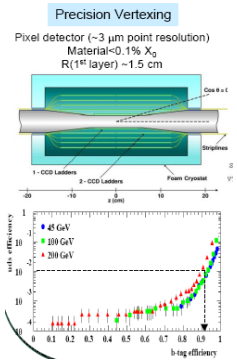






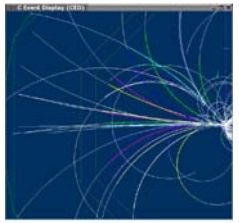


Challenges for ILC/CLIC detectors

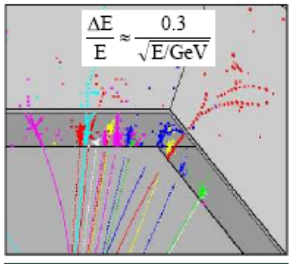


- Vertex $(h \to b\bar{b}, c\bar{c}, \tau^+\tau^-)$

  ~1/5 $r_{beampipe}$, ~1/30 to 1/1000 pixel size (ILC wrt LHC),
  vtx 2-3 cm (CLIC wrt ILC)

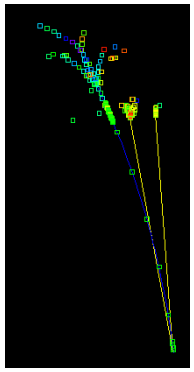


$$\sigma_{ip} = 5\mu m \oplus 10\mu m / p \sin^{3/2}\theta$$

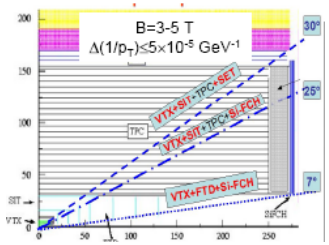


- Tracking $(e^+e^- \to Zh \to \ell^+\ell^- X; \text{incl.} h \to \text{nada})$

  ~1/6 material, ~1/10 resolution (ILC wrt LHC),
  B=4-5 T (CLIC wrt ILC)

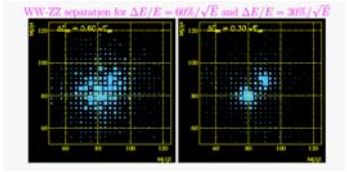


$$\sigma(1/p) = 5 \times 10^{-5}/\text{GeV}$$

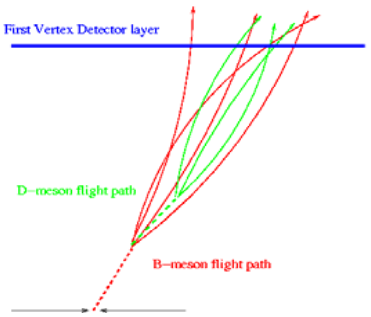


- Particle Flow, Jet Energy Rec. → Calorimetry

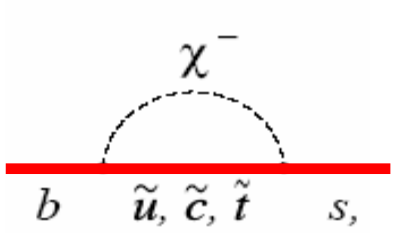
  ~1/2 resolution (ILC wrt LHC),
  Redesign Forward Region, HCAL 7,5 λ (CLIC wrt ILC)

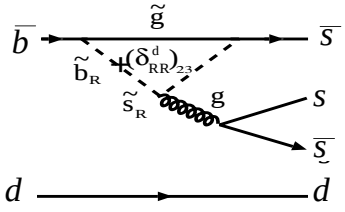


$$\sigma_E / E = 0.3/\sqrt{E(\text{GeV})}$$



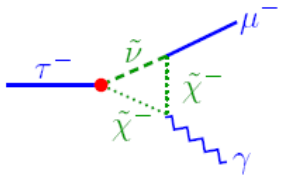
Super B Factories (Super B / Belle II)





$\phi, \eta', (KK)_{CP}$

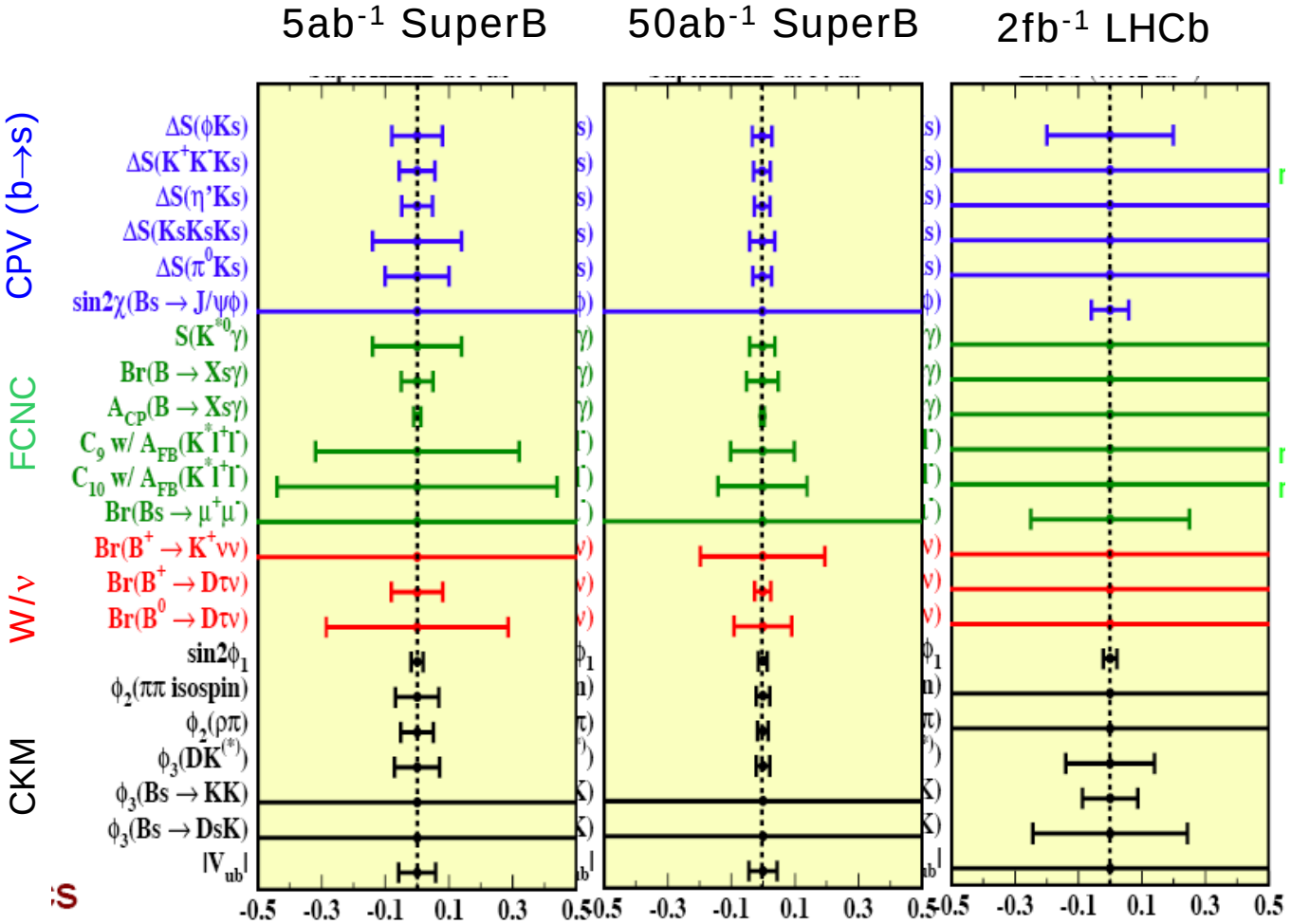
K^0_S



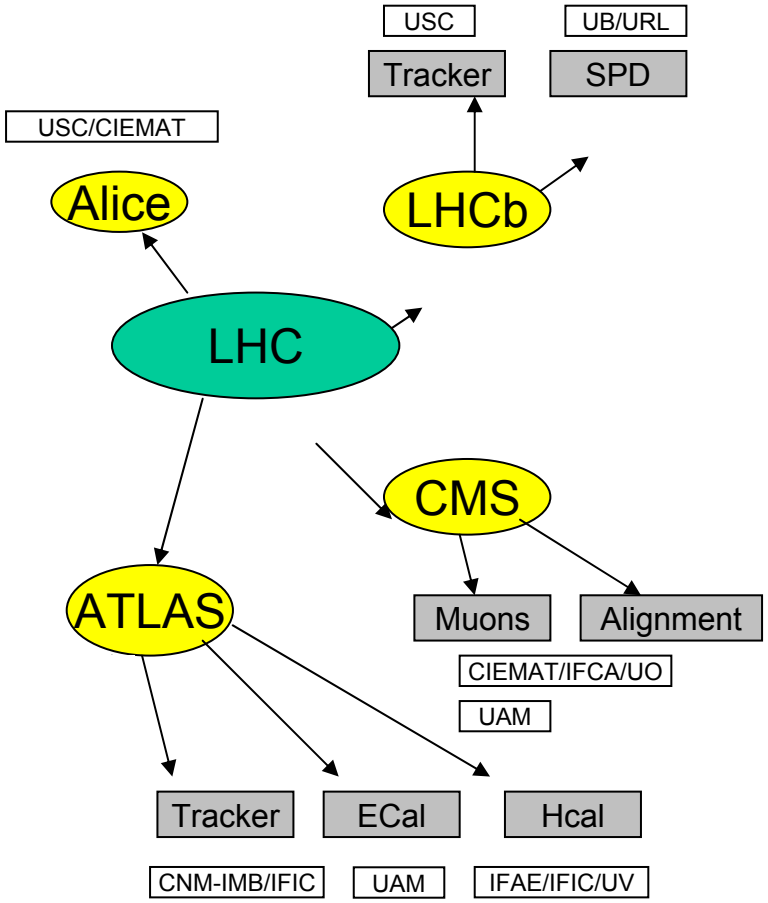
High Statistics

High sensitivity for rare processes

High sensitivity for processes with higher scales

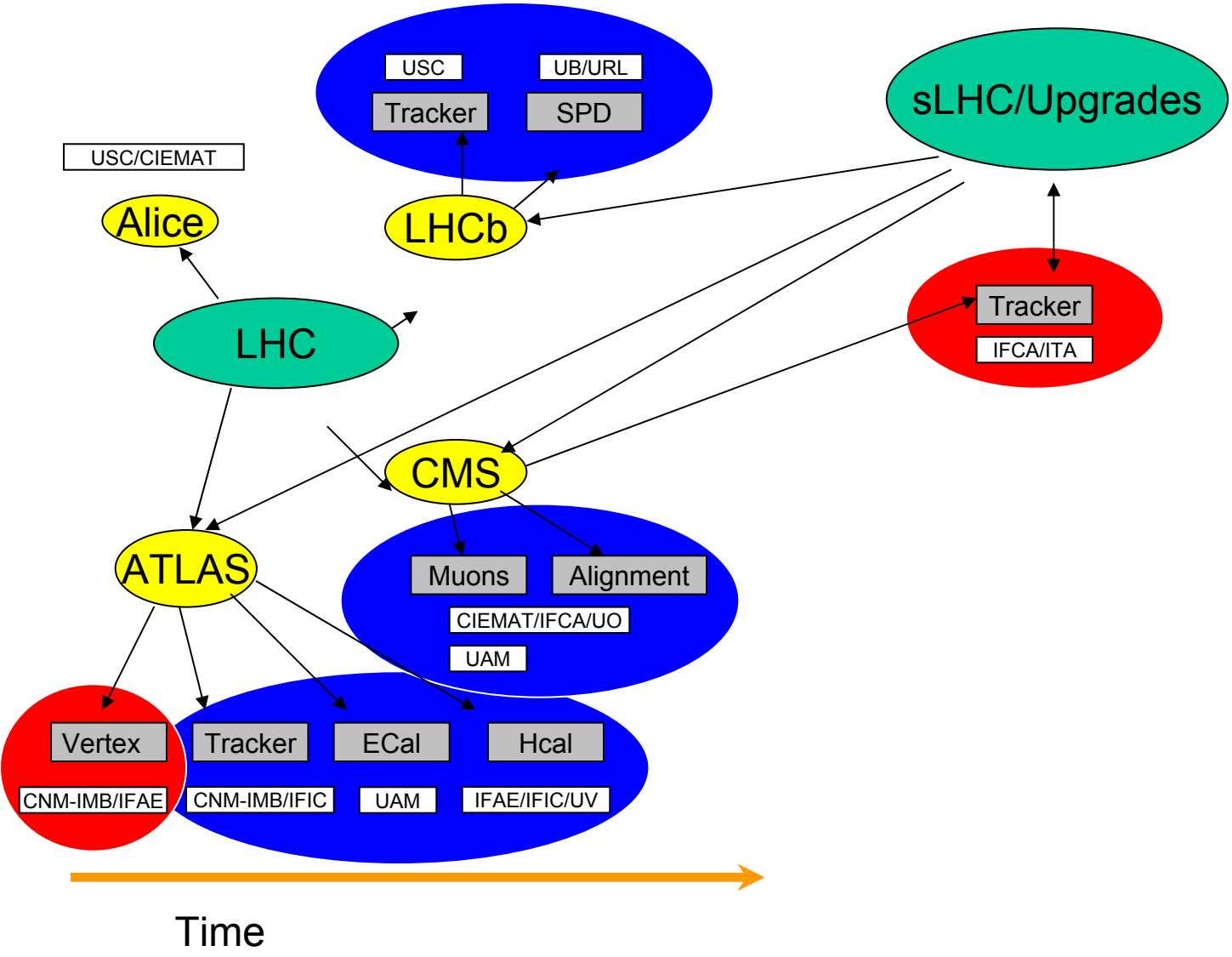


Spanish Participation: LHC

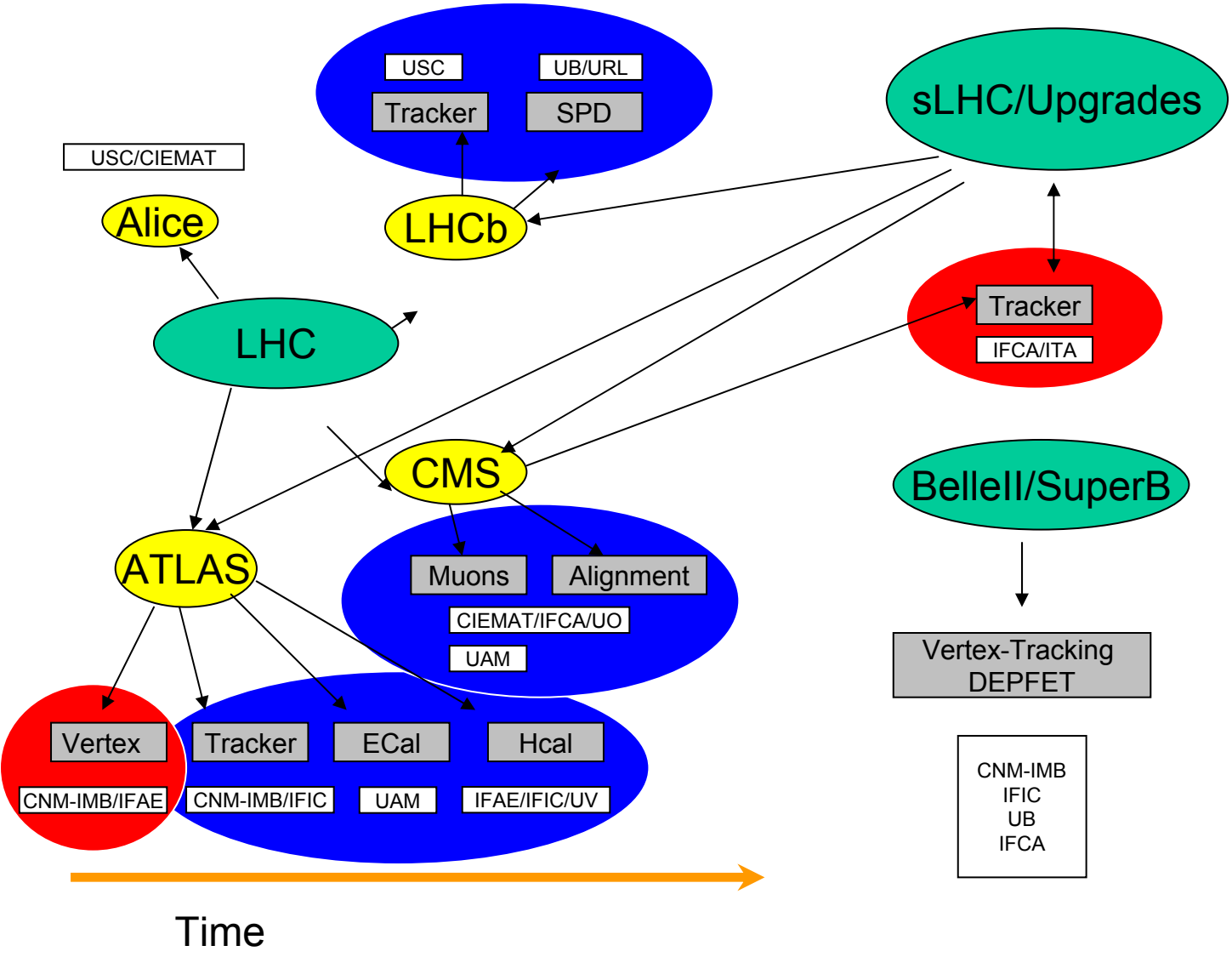


Time

Spanish Participation: LHC, sLHC/Upgrades

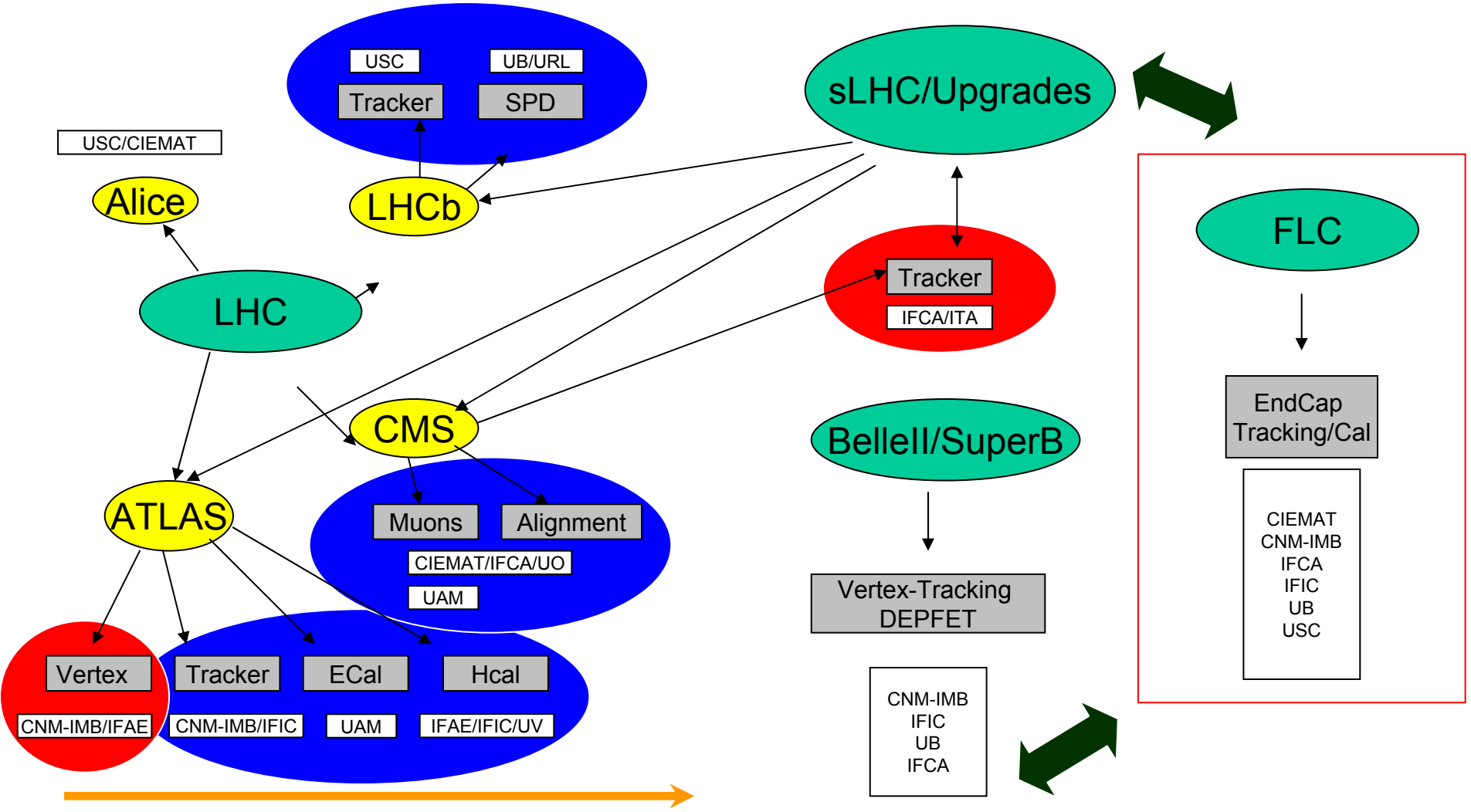


Spanish Participation: LHC, sLHC/Upgrades, BelleII/SuperB



Spanish Participation: LHC, sLHC/Upgrades, BelleII/SuperB, FLC

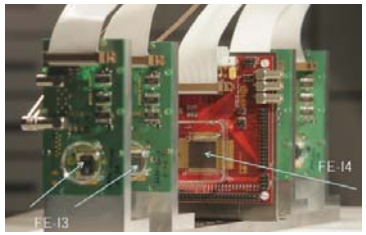
Key words: *Synergy, Optimization of Resources, Coordination*

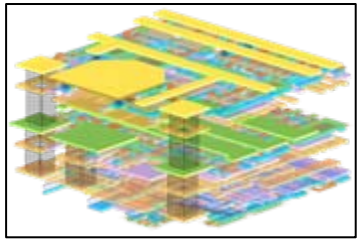
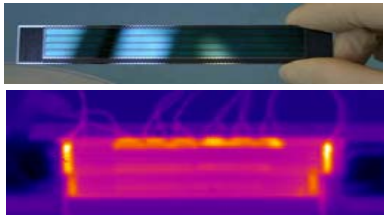


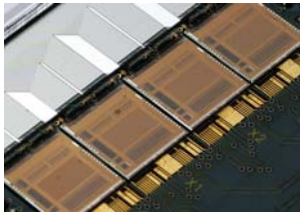
Resources: AIDA 2011-2014

AIDA
Advanced European Infrastructures for Detectors at Accelerators
http://aida.web.cern.ch/

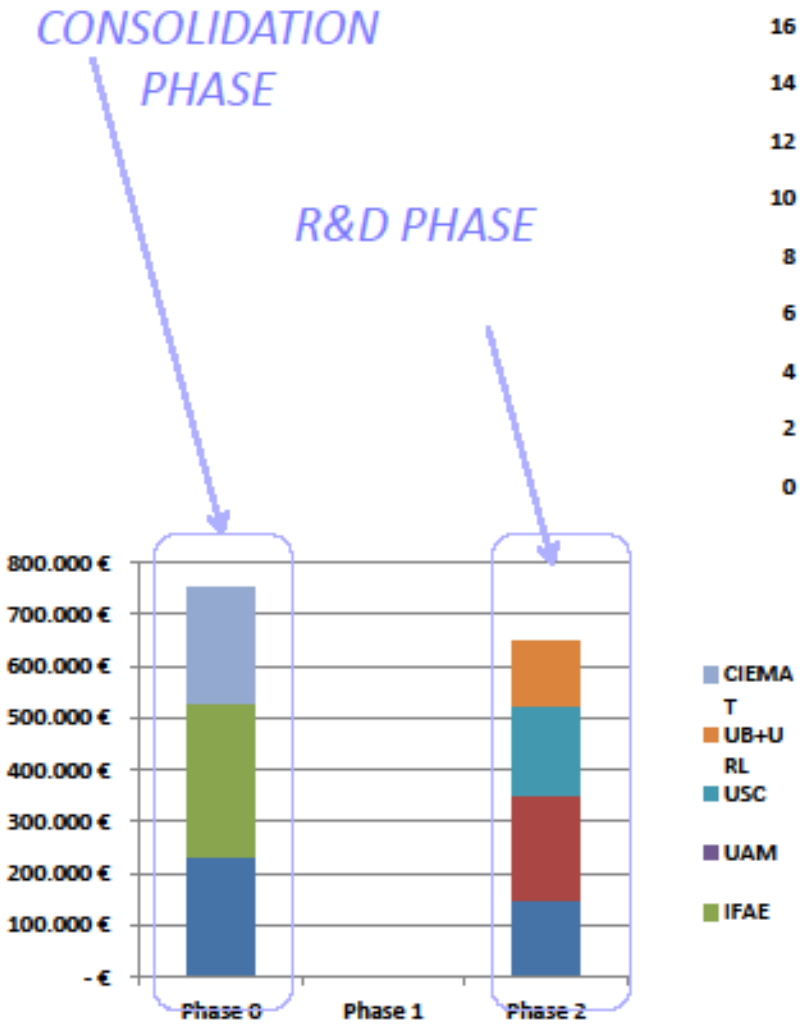
- A European network to create infrastructure that will boost detector R&D for applications in future collider experiments (and accelerator-based neutrino experiments)
- Follow-up and extension of the EUDET network. Involving the whole community: ILC/CLIC, LHC upgrade, Super B-factories, accelerator-based neutrino experiment
- Start data: February 2011. Duration: 4 years
- Participants: over 80 institutes from 23 countries
- Total budget: > 25 Million € (8 Million € EU funded)
- Spanish involvement:
  - 3 Work Packages, with bulk of the effort on Si position sensitive devices
  - One WP leader (M. Vos, IFIC) and the chair of the Collaboration board (I. Vila, IFCA)
  - 391K €, ~ 5% EU contribution
  - 7 institutes (CIEMAT 26K €, IMB-CNM 50K €, IFAE 26K €, IFCA 88K €, IFIC 127K €, UB 44K €, USC 30K €)

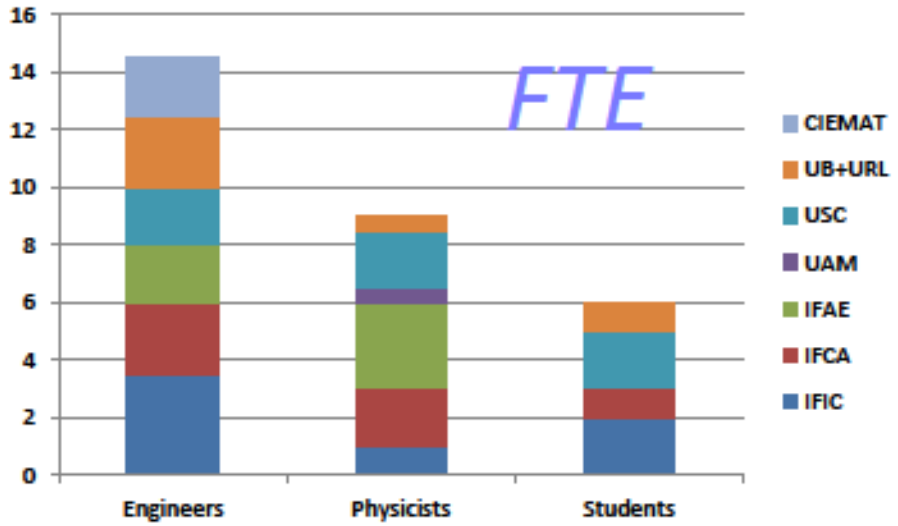




Resources sLHC-Upgrades 2010-2013 (I. Vila 7th Oct. RECFA)





Resources for period 2010-2013:

- 29,5 FTE
- 1,4M € for Detector R&

Organization and Coordination:

Follows present group participation inside the LHC experiments

Resources: Linear & B-Factories, National Plan 2011-2013 (FPA)

2010 Request at National Plan (FPA), covering the period 2011-2013:

- 65 physicist/engineers in the funded projects. 30 are permanent.
- 48 FTE (73% dedication of 65). Shared with LHC experimental projects.
- 4 PhD fellows were granted (2 Det + 2 Acc.).
- 1,5M € for Detector R&D
- 0,8M € for Accelerator R&D

A stable community over the last 5 years

Participation in the National Plan projects for the period 2006-2008

	Accelerator Particle Physics	Astroparticle Physics	Nuclear Physics	Comp./GRID	R&D + M.Phys. Detectors Accelerators
Doctors	88	67	84	17	41
PhD Students	64	33	23	4	6
Engineers, technicians, etc..	22	13	15	19	9
Collaborators	2	21	11	6	4
Total	**176**	**134**	**133**	**45**	**60**
Permanent Staff	50	32	48	11	28
Ramón y Cajal	9	9	4	1	3
Juan de la Cierva	5	5	6	0	1

Scientific Production & Visibility

For Instance LCWS11 workshop (Theory+Detectors R&D+Accelerators):

- 16 Parallel talks (3 theo.+8 R&D +5 Acc.)
- 2 Summary talks (1 theo. + 1 R&D)
- 1 Plenary talk (R&D)
- 4 Working Group Conveners

Future Colliders: Linear & B-Factories, Organization and Coordination

Three National Networks:

- R&D for Future Colliders (Detectors + Accelerators + Theory)
- Flavor Physics (Detectors + Theory)
- LHC, Experiment & Theory

R&D for Detectors and Physics:

- ILC, End Cap: DEPFET Coll. (Pixels), SiLC (Tracker), CALICE (Calorimeter)
- Belle II, DEPFET Coll.
- CLIC, Physics Benchmark, End Cap, Mechanical Structures
- ILC/CLIC/sLHC (very long term), 3D sensors, APDs, TimePix

European Projects:

- EUDET (R&D for detectors which is finished)
- AIDA (R&D for detectors, present)
- ENVISION-ENLIGHT (R&D for detectors, Medical Physics)

R&D for Accelerators:

- ILC (Test Facility ATF2), OTR + FONT4 (IFIC), TESLA500+MLQ (CIEMAT)
- CLIC (Test Facility CTF3), PETS+KICKERS (CIEMAT), BPS (IFIC. UPC)

European Projects:

- EUCARD (R&D for accelerator, present)
- PARTNER-ENLIGHT (medical Physics, present)
- TIARA (Accelerator Network)

Future Colliders: Linear & B-Factories, Organization and Coordination

International Representation:

- FALC (Funding Agencies for Large Colliders), Francisco Del Aguila
- ECFA chair for the Linear Collider Study, J. F. (WWS-OC European contact)
- ILD Executive Board, Forward Tracker, Alberto Ruiz
- AIDA chair of the Collaboration Board, Ivan Vila
- AIDA WP9 and Depfet Linear Collider Coordinator, Marcel Vos

National Coordination:

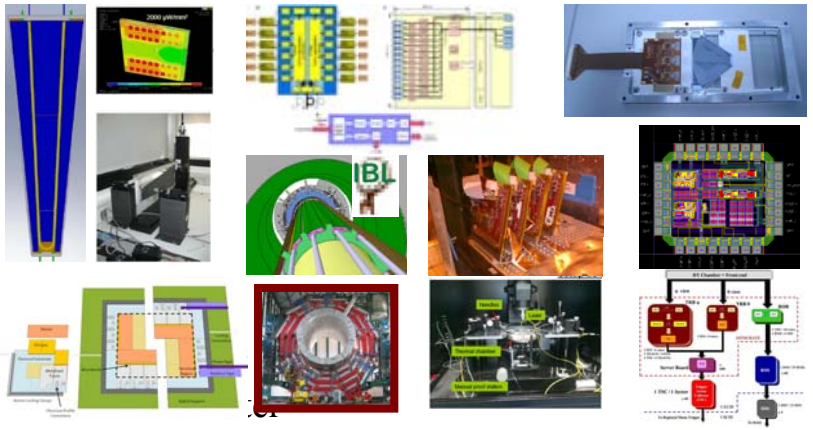
- Future Linear Collider Network Coordinator, Alberto Ruiz
- Flavor Network Coordinator, Francisco Botella
- Principal Investigators of projects from the National Plan

web page of the network: http://ilces.ific.uv.es

Workshop Organization and Participation:

- ECFA-ILC/GDE workshop in Valencia, November 2006
- LCWS11 workshop in Granada, 26-30 September 2011
- National Network for Future Linear Colliders workshops, 6 in the period 2008-2011 (santander, Santiago de Compostela, Barcelona, Madrid, Valencia, Granada). Next meeting in Zaragoza, December 2011
- CPAN workshops participation as specific community

Future Colliders: sLHC-Upgrades (backup slides)



ATLAS - IFAE & IMB-CNM

- Vertex-IBL, New 4th pixel layer (2013): validate 3D sensors, bump-bonding, sensor characterization, power distribution

ATLAS - IFIC & IMB-CNM

- Forward Si tracker: sensor & thermal mechanics,
- TiCal: readout off-detector electronics

CMS - CIEMAT & UAM

- TIM and ROS systems: Readout and Trigger

CMS - IFCA & ITA

- New Outer Tracker: Sensor assessment,
- Integration: Power distribution,
- Monitoring stability/alignment: Optical fiber system

LHCb - UB & URL

- Calorimeter: accommodate readout for 40 MHz,
- SiPM readout ,
- Synergies with CTA

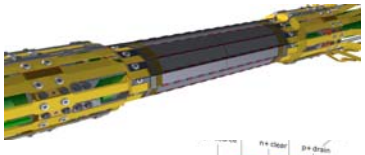
LHCb - USC

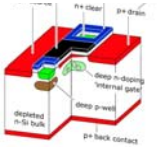
- Vertex-Velo upgrade for 40 MHz, Velopix (timepix) & μ-strips
- R&D: timepix, μ-strips

Future Colliders: Linear & Super B-factories (backup slides)

Silicon for Large Colliders

IFIC, IFCA (since 2005), UB, IMB-CNM, USC, ITA
IFCA→EUDET member, several associates
New EU project: AIDA





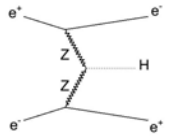
Spanish participation in DEPFET Coll.
IFIC (since 2005)
UB, IMB-CNM (since 2008)
IFCA (mechanical alignment and integration)

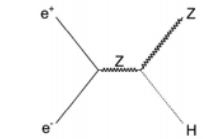
Timepix: USC

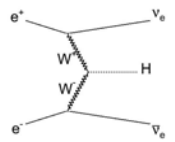
CIEMAT

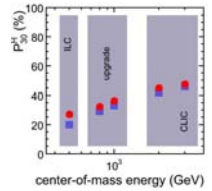
Coordinated effort :

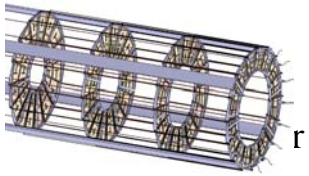
- Regular meetings (network), strategy
- Funding/project
- R&D interests, cooperation, benchmarks
- Design of the Forward Region for LC detectors

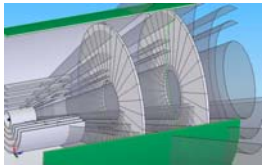


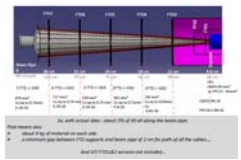


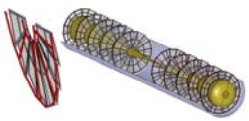


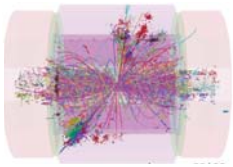


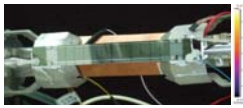


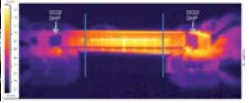




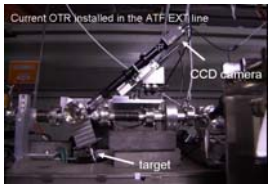


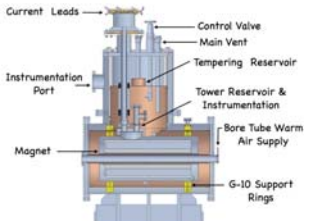






Future Colliders: Accelerator R&D (backup slides)





IFIC, ILC, ATF-ATF2

- Beam Dynamics Studies and commissioning of EXT line (LAL, KEK, SLAC)
- Instrumentation: New Multi-OTR system (SLAC, KEK)
- BPM with micro-movers for FONT4 (KEK, JAI)

IFIC-UPC, CLIC-CTF3

- BPM's for the TBL (CERN)

CIEMAT, CLIC-CTF3

- Quadrupole Mover (CERN)
- PETS (CERN)
- Orbit Correctors (CERN)
- Kickers (CERN)
- SEPTA (CERN)

CIEMAT, ILC

- TESLA500 (SLAC)
- Cooling of Superconducting Magnets

Future Colliders: Physics and Theory Coordination

Theory groups in Spain involved in LC/SuperB/Belle physics:

	Barcelona	Granada	Madrid	Santander	Valencia	Zaragoza
Phenomenology (also LC rel.)	+	+	+	+	+	+
LC specific calculations	+			+		
red ILC		+		+	+	
SuperB/Belle calculations			+	+	+	+
red Flavor		+	+	+	+	

Workshops relevant for LC:

LCWS11:
Linear Collider World Conference 2011
organized by Granada theory group (09/2011)

LHC2TSP:
From the LHC to Tera Scale Physics
workshop series about the implications of early LHC data for future colliders, input for the European strategy group
co-organized by Santander theory group (2011 - 2012)

HDays11:
Higgs Days at Santander
workshop on Higgs physics at the LHC and the LC
organized by Santander theory group (anual from 2008 on)

Future Colliders: Theory in Spain 2

LHC/sLHC, results & Interprtation

Marie Curie Initial Training Network **PITN-GA-2010-264564** (2011–2014)

EU Coordinator: G. Rodrigo (10 countries, 30 institutions, 3 industry partners, 150 researchers)

USC University

Summary

- **In Spain, an important effort in the R&D activities for future colliders at the High Energy and Intensity frontiers is being made for detectors, accelerators and physics studies**
- **The national networks are found very useful to help in the coordination. It allows to have common discussions, optimize resources and find synergies**
- **Spanish groups are well prepared to participate in any future collider project: sLHC-Upgrades, ILC/CLIC, BelleII/SuperB**
- **Future projects realization will depend mainly on LHC physics results and our community will take an active part in the decision**
- **Spanish participation in future colliders is internationally visible and relevant.**
- **Good participation in EU projects, AIDA, EUCARD, TIARA …**

Recognition has always been important

Sir Ernest Schakleton

The Imperial Trans-Antarctic Expedition (1914–17),

Also known as the Endurance Expedition is considered the last major expedition of the Heroic Age of Antarctic Exploration.

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Sir Ernest Schakleton

The Imperial Trans-Antarctic Expedition (1914–17),

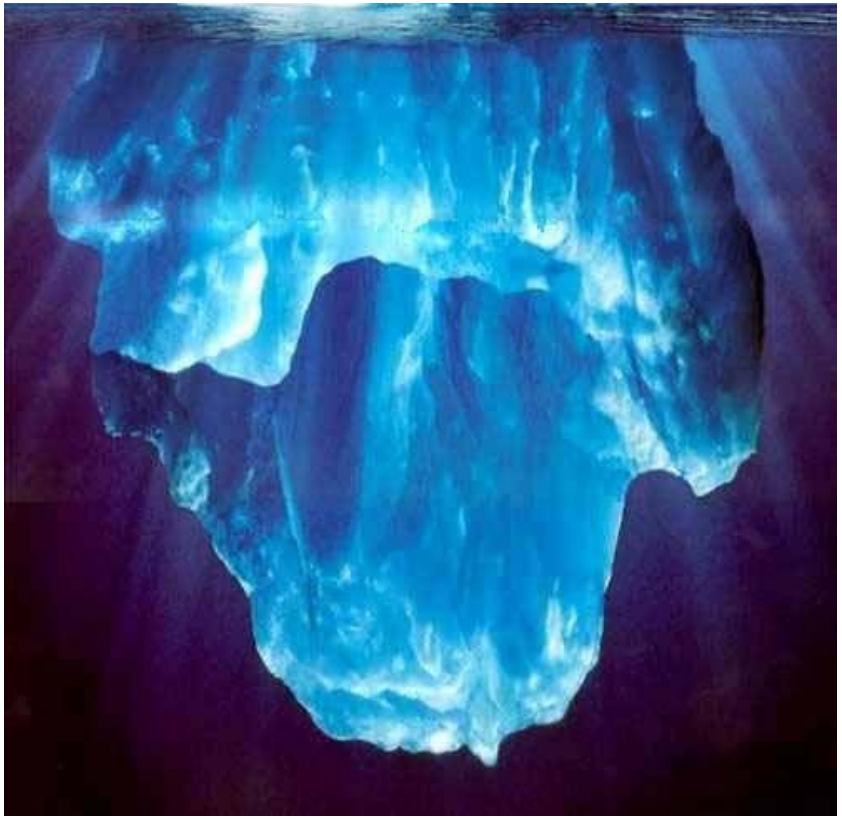
Also known as the Endurance Expedition is considered the last major expedition of the Heroic Age of Antarctic Exploration.

For a crew of ~30 people more than 4000 applications were received

Today`s R&D Future Colliders adventure: **Men and Women are wanted**

Backup Slides

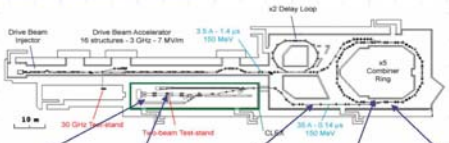
R&D Contributions from Spanish Groups for Future Colliders



Accelerator R&D, CIEMAT

ACTIVIDADES EN CTF3 (CLIC)

DESCRIPTION: CTF3 is an experimental facility to prove the two-beam acceleration scheme proposed for CLIC.



QUADRUPOLE MOVER PETS ORBIT CORRECTORS KICKERS SEPTA

FUNDING:

FPA2004-20954-E (2004-2006) 432.000 €

FPA2007-29109-E (2007-2008) 410.000 €

Grant Agreement 227579 (2009-2013) 114.000 €

FPA2010-21456-C02-02 (2011-2013) 415.000 €
(shared with ILC activities)

1

PETS TBL

First prototype assembly

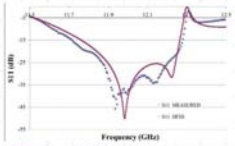
Test Beam Line (TBL)

The Test Beam Line aims to study the beam stability during deceleration.

The PETS (Power & Extraction Transfer Structure) extracts the RF power from the drive beam and transfers it to the main beam.

CIEMAT contribution consists of:

- Engineering design
- Complete fabrication and RF characterization of first prototype
- Partial fabrication and assembly of 3 units of the first series of 8.



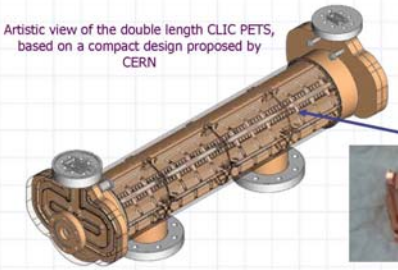
RF characterization

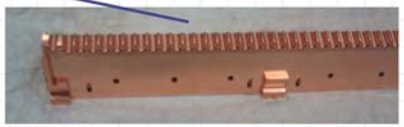
Cooling pipes and waveguides

CLIC PETS

CLIC PETS will be shorter (~250 mm) than TBL ones (~800 mm) , since the drive beam current is highest than TBL one. CIEMAT is currently working on a new compact PETS design, which will be tested in a custom module in CTF3. In this module, PETS length is still twice (~500 mm) the final one for CLIC.

Artistic view of the double length CLIC PETS, based on a compact design proposed by CERN



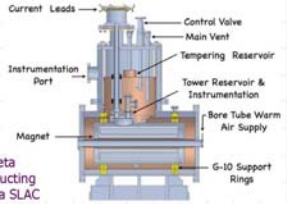


Detailed view of a real copper rod

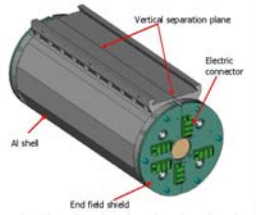
MAGNET PACKAGE FOR ILC MAIN LINAC

DESCRIPTION:

- CIEMAT developed a cos-theta type superconducting magnet package for TESLA500, which has been succesfully tested at SLAC to measure the magnetic axis stability. It might be used for ILC main linac.
- CIEMAT will explore an alternative design based on indirect cooling superconducting magnets to ease the cryomodule assembly.



Cos-theta superconducting magnet in a SLAC horizontal cryostat to measure the magnetic axis stability



Proposal of indirect cooled magnet design for ILC main linac (V. Kashikin, FNAL)

FUNDING:

FPA2002-00841 (2002-2005) 192.000 €

FPA2010-21456-C02-02 (2011-2013) 415.000 €
(shared with CLIC activities)

4

Accelerator R&D, IFIC-Valencia

IFIC

FLC Accelerator R&D at IFIC

GAP Accelerator Physics Group

http://gap.ific.uv.es/

RECFA 2011 1

Motivation in FLC:

Participate in the research and development of the required technologies for Accelerators for Future Linear Colliders (ILC, CLIC)

Accelerators (ILC, ATF2, CLIC, CTF3)

- Beam Dynamics studies and experiments
- Beam Instrumentation design, construction, calibration and integration including the associated electronics

RECFA 2011 2

FLC Current Activities

Beams Dynamics and Experiments

- Beam studies, realistic tracking simulations, control software developments and experiments in the multi-OTR system in the EXT line of the ATF2
- Realistic tracking simulations and control software developments for FONT4 (with micromovers) in ATF2
- Experimental performance studies of the BPMs in the TBL of CTF3
- Beam dynamics studies of DR and PDR stripline Kickers for CLIC

RECFA 2011 3

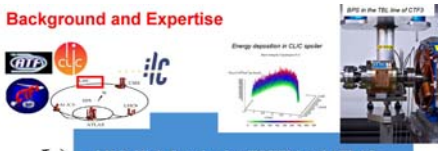
FLC Current activities

Beam Instrumentation

- Design, construction and calibration of the Multi-OTR system for EXT line of ATF2
- Contribution to R&D for the dipole mode cavity BPM for the MLI of ILC
- Contribution to conceptual design of a Drive Beam Decelerator BPM for the 1st CLIC module
- Design, Construction and calibration of DR and PDR stripline Kickers for CLIC

RECFA 2011

Background and Expertise



IFIC

- LHC: High-β optics for: TOTEM and ATLAS-Luminosity measurement and collimation studies
- ILC: BDS optics: e⁻e⁻ options and feedback
- ATF-ATF2: EXT line emittance growth beam studies, instrumentation (FONT4 micromovers, OTRs)
- CLIC and CTF3: collimation system and instrumentation (TBL BPMs)

RECFA 2011 5

FLC Funded National Projects at IFIC:

Participación en las actividades de I+D y de diseño para un FLC: acelerador y detector
- IP: A. Faus-Golfe, FTE: 6, FPA2005-02935, Total: 339.150€ (2005-2008)

Construcción, Testeo e Instalación de los monitores de posición del haz para la TBL del CERN
- IP: A. Faus-Golfe, FPA2007-31124E, Total: 220.000€ (2007-2008)

Desarrollo de Nuevas Tecnologías en Aceleradores y Detectores para los FLC en Física de Partículas
- IP: A. Faus-Golfe, FTE: 6, FPA2008-05979-C04-01, Total: 504.449€ (2009-2010)

Participación en el Desarrollo de Nuevas tecnologías en Aceleradores para los Futuros Colisionadores en Física de Partículas
- IP: A. Faus-Golfe, FTE: 6, FPA2010-21456-C02-00, Total: 312900€ (2011-2013)

RECFA 2011 6

FLC Funded International Projects at IFIC:

Coordinated Accelerator Research in Europe CARE.
- IP: R. Aleksan, EU: RII3-CT-2003-506395, Total: 15200000€ (2004-2008)

Study of the Machine-Detector Interface of the International Linear Collider.
- IP: A. Faus-Golfe, IN2P3 05-13, IN2P3 06-06 , IN2P3 07-02, IN2P3 08 FT:4, Total: 17500€ (2005-2009)

European Design Study Towards a Global Linear Collider.
- IP: E. Elsen, EC Research Infraestructures Action 011899 EUROTeV (RIDS) (2005-2008)

European Collaboration for Accelerator Research and Development EUCARD
- IP: J.P. Koutchouk, EU Commission- 227579, Total: 10M€ (2009-2012)

RECFA 2011 7

Personnel

IFIC

- **Dr. Angeles Faus-Golfe** (Angeles.Faus-Golfe@ific.uv.es) Project leader
- **Juan Jose Garcia Garrigós** (aicraG.ojnauJ@ific.uv.es) Electronic Engineer
- **Cesar Blanch Gutierrez** (bcnalB.raseC@ific.uv.es) Mechanical Engineer
- **Dr. Javier Resta Lopez** (Javier.Resta@ific.uv.es) Research Assistant (Juan de la Cierva)
- **Dr. Luisella Lari** (Luisella.Lari@ific.uv.es) Research Assistant (EUCARD)
- **Silvia Verdú Andrés** (udreV.aivliS@ific.uv.es) PhD Student (PARTNER)
- **Javier Alabau Gonzalvo** (uabalA.reivaJ@ific.uv.es) PhD Student (Bancaja)
- **Carolina Belver Aguilar** (revleB.ailoraC@ific.uv.es) PhD Student (FPI)
- **Alfonso Benot Morell** (Alfonso.Benot@ific.uv.es) PhD Student (Especializacion Infraestructuras Científicas y Organismos Internacionales)

RECFA 2011 8

Detector R&D, Santiago de Compostela University

Future collider instrumentation activities

Abraham Gallas

USC UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

2009-2010. *FPA2008-05979-C04-03*

USC UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

- **DEPFETs**
  - Tests in the lab & in particle beams.
  - Design of the LV prototype for Belle II.
  - Grounding system studies for Belle II.
- **Simulation studies for ILC:**
  - Studies for the FTD of the International Linear Collider.
- **Irradiation studies:**
  - DEPFET ^{60}Co source up to 10 MRAD
- **People**:
  - P. Vázquez, E. Pérez, J. Visniakov, J. Caride*, C. Iglesias*.

26/10/10 Abraham Gallas (*) Left the project during 2010 2

2011-2013. *FPA2010-21549-C04-02*

USC UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

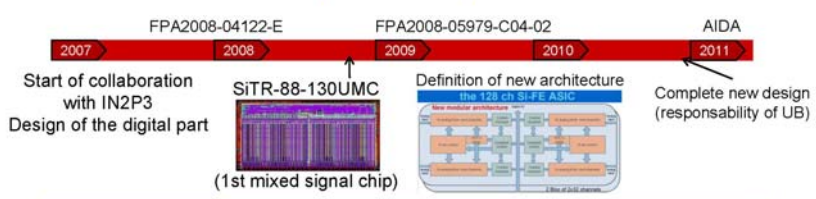
- **Timepix pixel sensors**
  - Sensor thinning down to 150 µm p-in-n & n-in-p achieved (IMB-CNM). Test beam activities ongoing. Next step 50-80 µm starting 2012
  - Minimal guard ring design started (IMB-CNM), results mid 2012
  - Construction of a first tile (2x1 ASICs) started, results mid 2012
  - Thinning of ROC (50µm). Starting 2012
- **Fine pitch thin micro-strip sensors:**
  - First prototypes build with 30-40 µm pitch. Being test with particles during 2011.
  - Construction and testing of prototype 25 µm (50 µm with intermediate strip) in collaboration with IFCA. 2012.
- **Irradiation studies:**
  - Timepix pixel sensors: Irradiations starting 2012
  - APDs with ^{60}Co source at Santiago starting end 2011 in collaboration with UB
- **People**: A. Gallas, P. Vázquez, E. Pérez, D. Esperante*, J. Visniakov*. P. Rodríguez, A. Dósil (joined 01/09/2011).

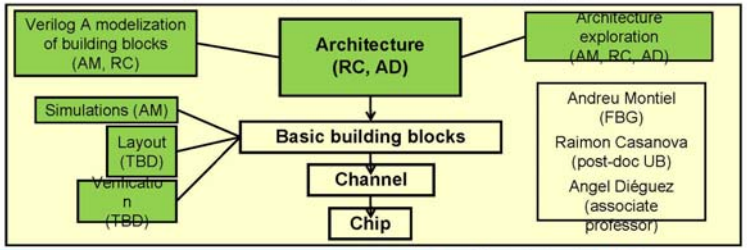
26/10/10 Abraham Gallas (*) Left the project 31/08/2011 3

Detector R&D, University of Barcelona

UNIVERSITAT DE BARCELONA

SiLC timeline and current personnel responsible



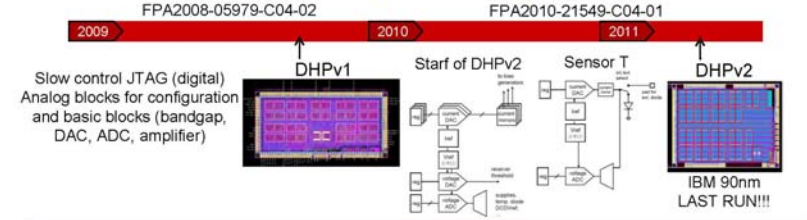


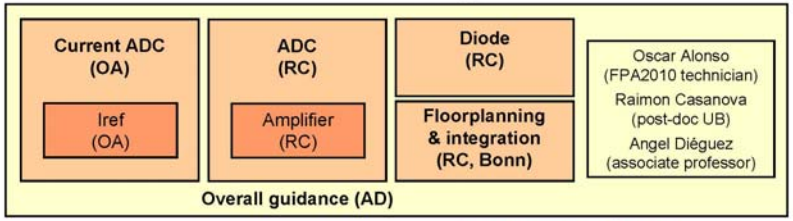
ICCUB

Department of Electronics

UNIVERSITAT DE BARCELONA

DEPFETs timeline and current personnel responsible





ICCUB

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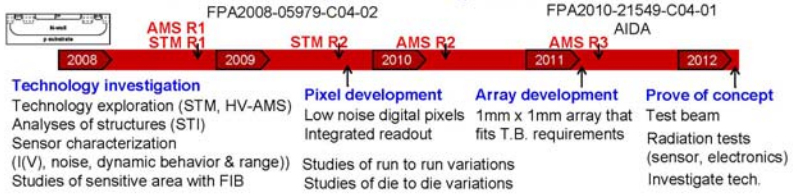
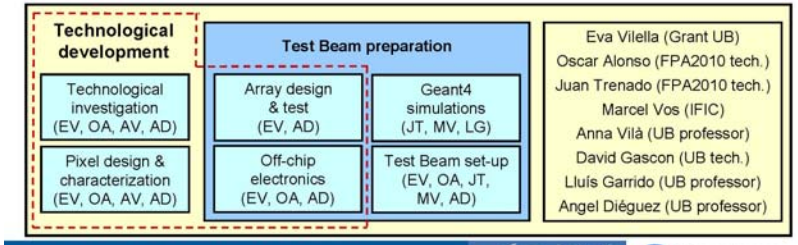
UNIVERSITAT DE BARCELONA

APDs timeline and current personnel responsible

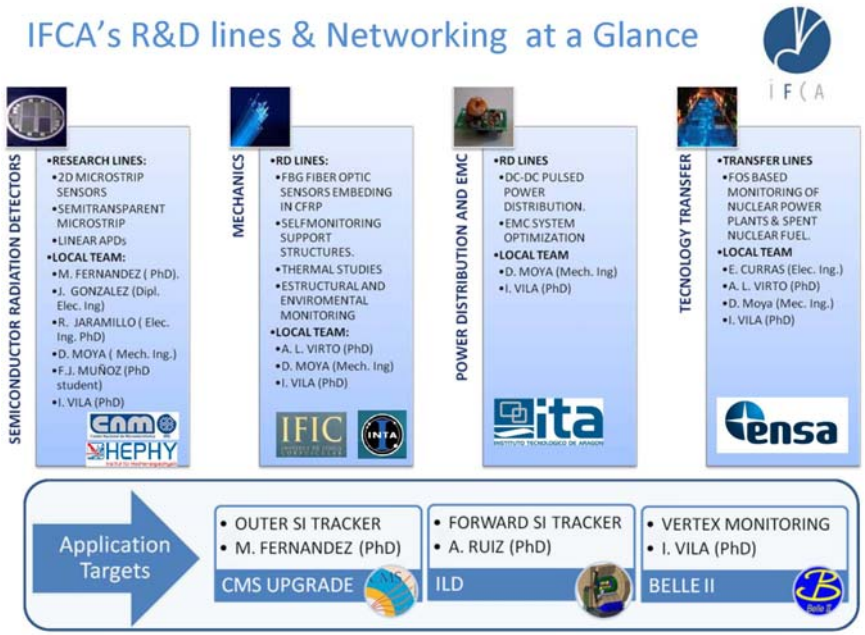


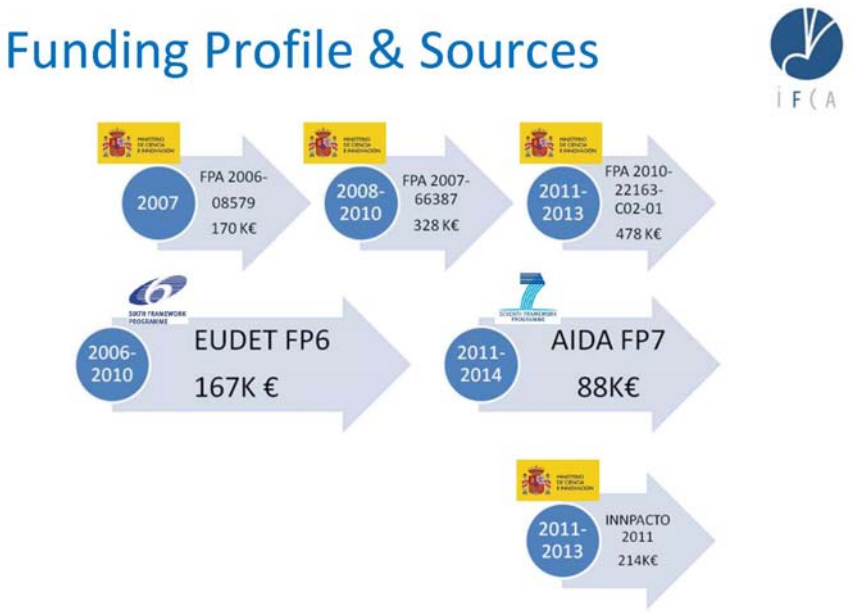


ICCUB

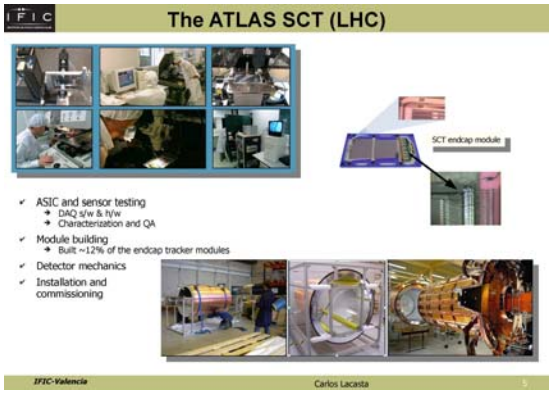
Department of Electronics

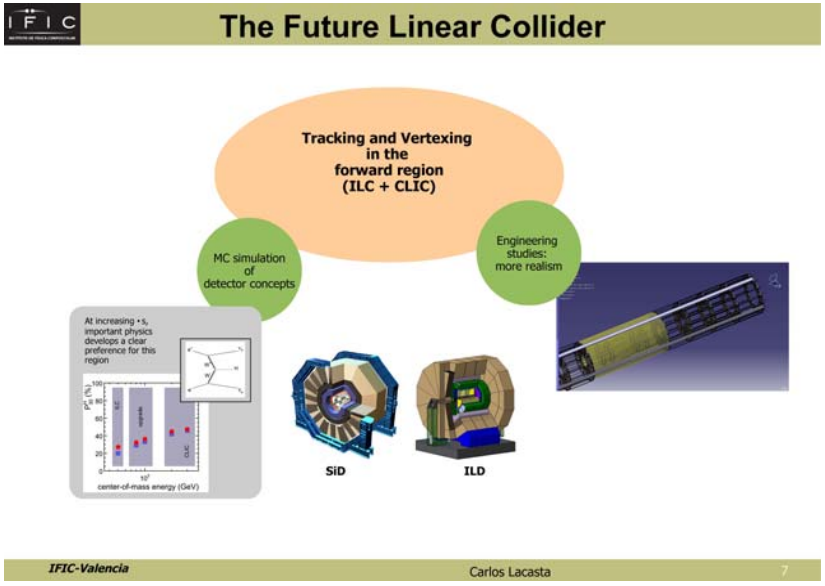
Detector R&D, IFCA-Santander

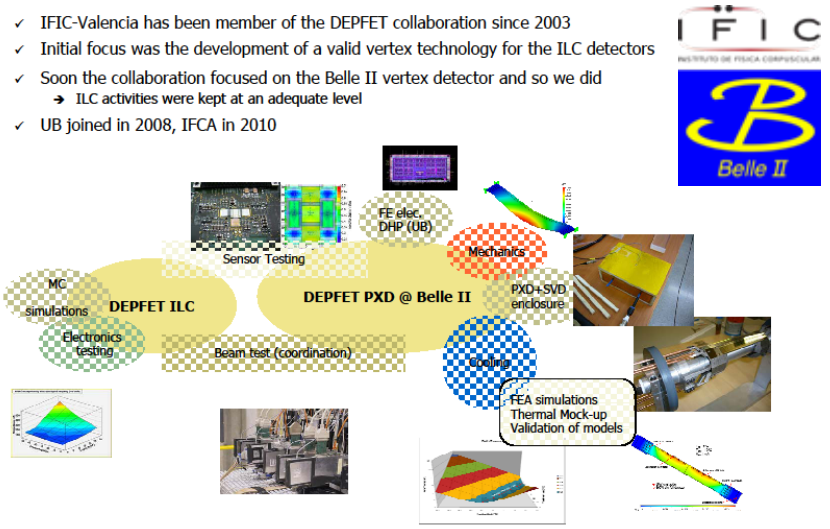




Detector R&D, IFIC-Valencia







Detector R&D, CIEMAT

GOBIERNO DE ESPAÑA · MINISTERIO DE CIENCIA E INNOVACIÓN · Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas · CALICE Calorimeter for ILC

Member of CALICE (CAlorimeter for Linear Collider Experiments) Collaboration since 2007
Involved in the development of a SemiDigital Hadron Calorimeter (SDHCAL):
GRPC (with SemiDigital Readout) + Stainless Steel

Main work activities

Responsible of the SDHCAL mechanics:

- Mechanical design of SDHCAL
- Numerical simulations
- Design of tooling for a 1m^3 prototype
  - For Assembly & Handling
- Precise machining & fabrication of components and quality checks
- Tooling construction
- Final assembly of the 1m^3 prototype mechanic structure
- GRPC Integration & cabling (at CERN)

Test beam & Data Analysis

Budget

FPA 2007-29117-E	1 year	12000 EUR
FPA 2008-02142	2 years	158752 EUR
FPA 2010-19836	3 years	171699 EUR
AIDA	4 years	26190 EUR

People

MaryCruz Fouz	Researcher (IP)
Jesús Puerta	PostDoc
Enrique Calvo	Mechanical Engineer
Jesús Marín	Electronic Engineer
Jorge Berenguer	PhD Student
CIEMAT Technicians	

Detector R&D, AIDA

AIDA Advanced European Infrastructures for Detectors at Accelerators

http://aida.web.cern.ch/

A European network to create infrastructure that will boost detector R&D for applications in future collider experiments (and accelerator-based neutrino experiments)

Follow-up and extension of the EUDET network

Involving the whole community: ILC/CLIC, LHC upgrade, Super B-factories, accelerator-based neutrino experiment

Start data: February 2011

Duration: 4 years

Participants: over 80 institutes from 23 countries

Total budget: > 25 Million € (8 Million € EU funded)

AIDA is co-funded by the European Commission within the Framework Programme 7 Capacities Specific Programme, Grant Agreement 262025

AIDA Advanced European Infrastructures for Detectors at Accelerators

Work packages to:

- enhance contact with industry
- provide a common forum for development of 3D-integrated devices
- access to irradiation and test beam facilities
- upgrade of (CERN) beam lines
- creation of infrastructure for characterization of prototype devices

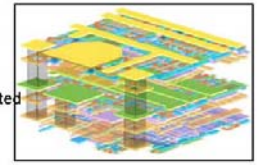
Spanish involvement:

- 7 institutes (CIEMAT, CNM, IFAE, IFCA, IFIC, UB, USC)
- 3 Work Packages, with bulk of the effort on Si position sensitive devices
- One WP leader (M. Vos, IFIC) and the chair of the board (I. Vila, IFCA)
- 476.000 · EU contribution ~ 5 %

AIDA is co-funded by the European Commission within the Framework Programme 7 Capacities Specific Programme, Grant Agreement 262025

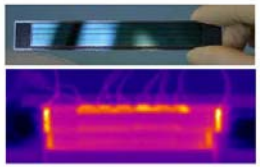
AIDA WP3 + WP 9.3

WP3 3D integrated chip design
CNM/UB/USC
WP9.3 pixel detectors
IFAE/IFCA/IFIC/USC

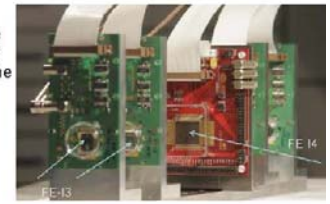


First working vertically integrated pixel read-out design (FNAL)

Ultra-thin 50 ❍m pixel devices and characterization of the thermo-mechanical properties
Courtesy: DEPFET collaboration



Characterization of the response in a beam of particles at CERN of the new read-out chip for the ATLAS pixel detector
Courtesy: ATLAS collaboration

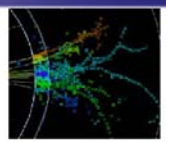


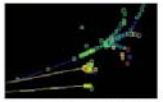
AIDA WP9.4/5

WP9.4 Silicon Tracking
IFCA/IFIC/CNM
WP9.5 Highly Granular Calorimetry
CIEMAT

Micro-strip detectors from WP9.4 are integrated with prototype calorimeters from WP9.5 in CERN beam line

CALICE 1 m3 Tungsten calorimeter in CERN beam line

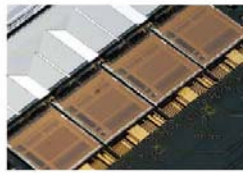




SiD simulation: 250 GeV jet and ❐ → ❐·❐ decay

CNM in-house infrastructure for the production of micro-strip detector

Integration of read-out IC and sensor



Physics LHeC, Santiago de Compostela University

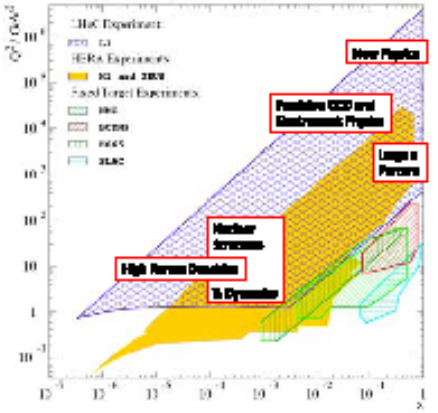
Large Hadron-electron Collider

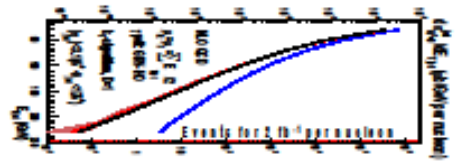
http://cern.ch/lhec

- **LHeC**: $e^{\pm}p/A$ accelerator to collide $e^{\pm}$ with the LHC beams at $\sqrt{s}$~1-2 TeV per nucleon.
- 2 accelerator proposals: linac (ERL) and ring, E_e=20-140 GeV.

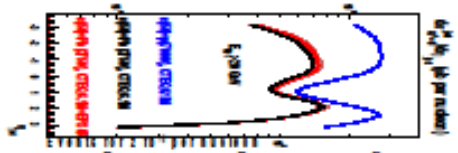
- 6 WGs: theory work on the physics of *Precision QCD and EW* and *Physics at High Parton Densities*: N. Armesto (convener of the HPD WG) and C. A. Salgado - Santiago de Compostela.

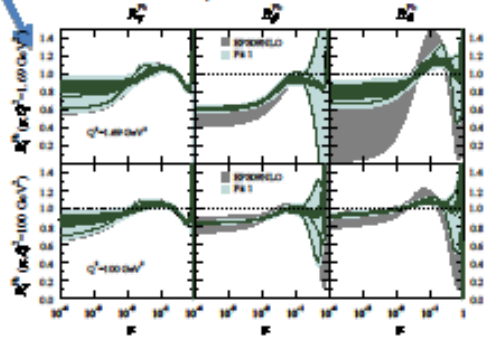
- **CDR** (sent to referees on 05.08.2011) to be submitted to CERN, ECFA and NuPECC, and LR/RR choice, before the end of the year.
- Project already included in NuPECC roadmap.
- Subsequent steps to be discussed next year: TDR, Collaborations.





Jets in γp/A



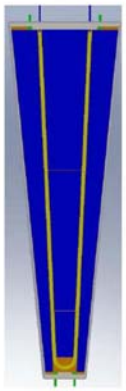


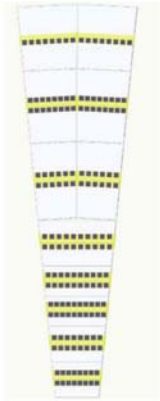
Nuclear pdfs

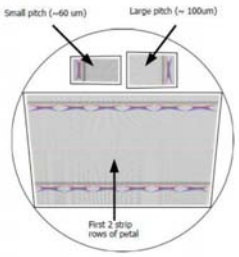
sLHC/Upgrades, IFIC Valencia

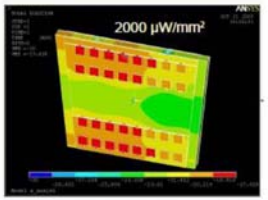
Atlas Upgrades: IFIC activities (1)

– Contribution to new **forward silicon tracker** (phase II): thermo-mechanical design & sensor prototyping with IMB-CNM.







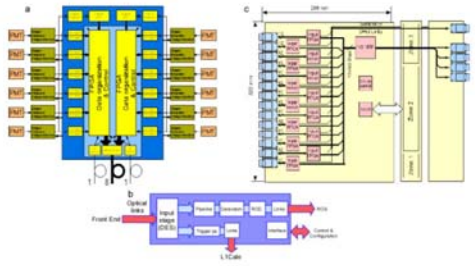


Atlas Upgrades: IFIC activities (2)

– Staged upgrade of **TileCal hadronic calorimeter**. IFIC contribution to readout (off-detector electronics)

– Full Digital readout:

- Radiation resistance and improved L1 Trigger
- a first demonstrator installed after LS1 and all the system available for phase II.
- Jointly with Lisbon (LIP) and U. Of Stockholm



sLHC/Upgrades, IFAE Barcelona

Atlas Upgrade: IFAE Activities (1)

IBL: new (4th) pixel layer mounted directly on beam-pipe

radius=33mm, same η coverage, 0.2m²

requires new (smaller) beam-pipe

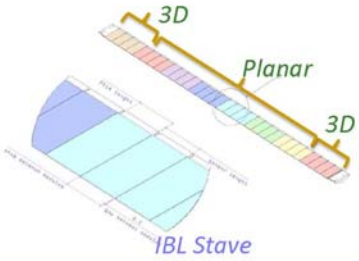
improves physics performance

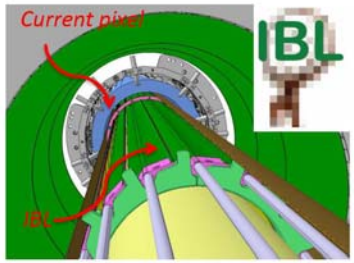
IFAE Responsibilities:

Sensor (quality control, characterization)

Bump-bonding

Power distribution system





MoU finalized this year

Install in LHC shutdown 2013

IBL Sensor technology target:

*75% planar pixels, **25% 3D pixels***

*50% of the 3D sensors to be produced at **CNM (Barcelona)***

IFAE led the effort to prove 3D technology for IBL

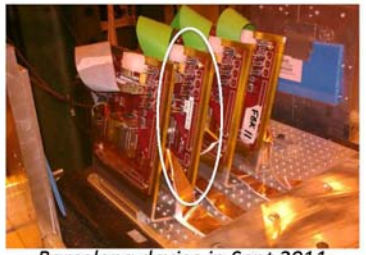
Atlas Upgrade: IFAE Activities (2)

Exhaustive program to validate 3D technology for IBL:

Irradiated sensors to IBL fluencies (5E15 neq/cm2)

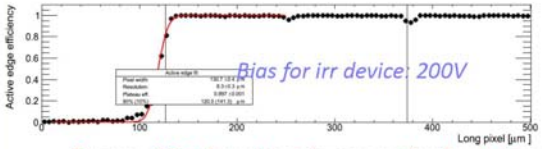
Pre/post irr characterization of devices

Test-beam campaigns to study performance of irradiated 3D sensors



Barcelona device in Sept 2011

CERN test-beam



Excellent performance of 3D sensors in terms of efficiency and charge collection (similar to planar sensors)

Proven 3D advantage in power budget, improvements in forward region being investigated

And beyond IBL... (LS2 and LS3)

3D sensors (inner layers)

n-on-p planar pixel sensors (medium layers)

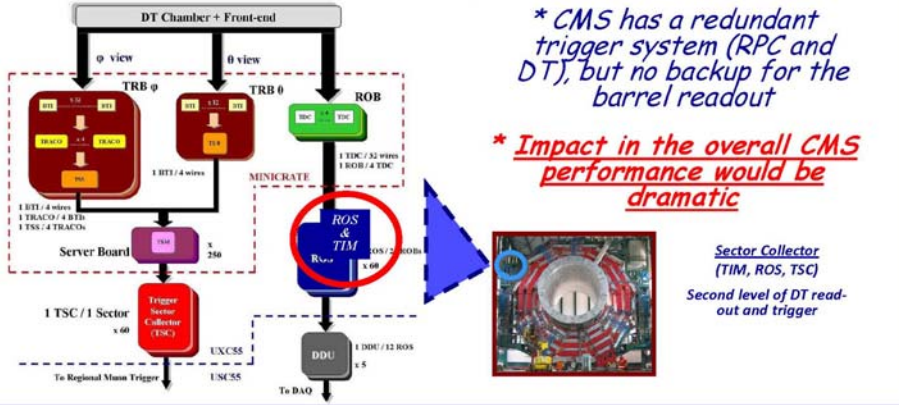
Active/slim edges, reduced pixel size

sLHC/Upgrades, CIEMAT

CMS upgrade: Ciemat & UAM activities (1)

Luminosity expectations have force to focus in the plan a) of our consolidation proposal:

* *TIM and ROS (both CIEMAT responsibilities) will not work properly at 6 10^{34} inside the cavern due to radiation (SEU MTBF ~ 30 min)*
* *Buffer occupancies will compromise ROS operation, a higher performance board needs to be produced (rad tolerant system needs long development time and would be very expensive)*
* *Failure in 1 TIM or 1 ROS jeopardizes large fraction of the detector (half a wheel and 1 sector)*



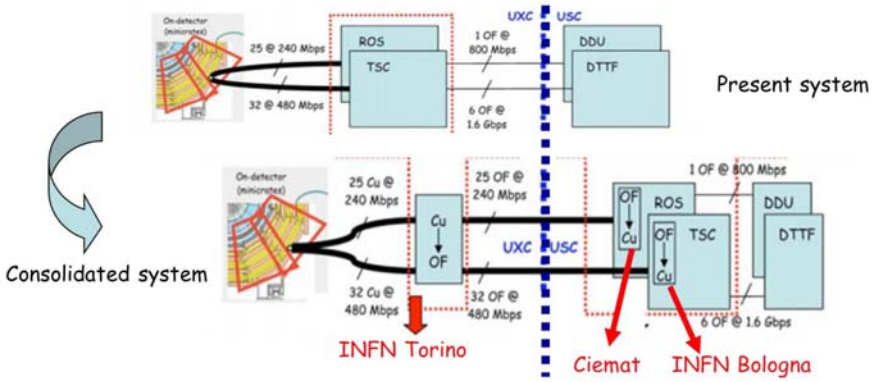
* *CMS has a redundant trigger system (RPC and DT), but no backup for the barrel readout*
* ***Impact in the overall CMS performance would be dramatic***

Sector Collector (TIM, ROS, TSC)

Second level of DT read-out and trigger

CMS upgrade: Ciemat & UAM (2)

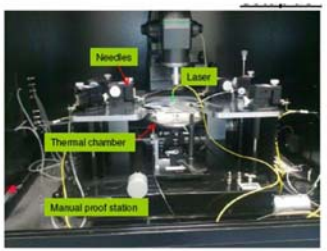
- Present schedule does not allow to produce a new ROS in time
- Plan is to relocate the Sector Collector in USC in 2013-2014 shutdown
- Make a simple 1 to 1 copper to OF conversion at UXC => **CuOF** and back in USC => **OFCu**
- **This will allow operating safely during 2015-2018 period**
- Future maintenance tasks are compatible with present plan and become much cheaper

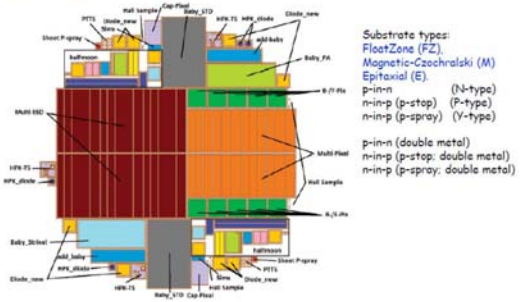


sLHC/Upgrades, IFCA Santander

CMS Upgrade: IFCA Activities (1)

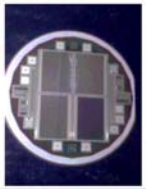
- Complete new outer tracker for phase II: dealing with higher occupancies and added LV1 trigger capabilities.
- IFCA group contributing to sensor assessment campaign ("HPK wafer"): irradiation effect, material and layout options.
- Joint work with CERN SiliconLab

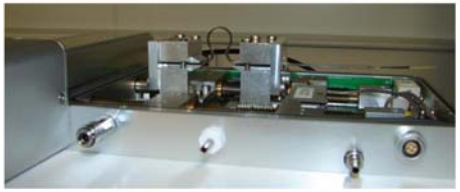




CMS Upgrade: IFCA Activities (2)

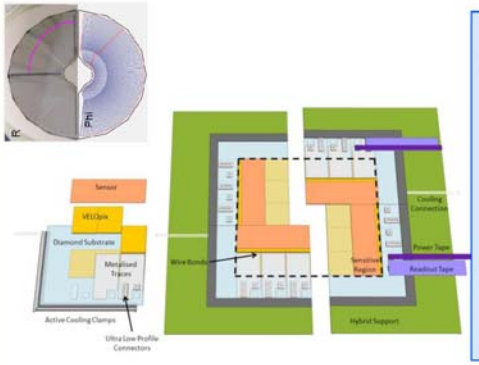
- Other contributions:
  - New microstrips sensors: semitransparente, 2D (collaboration with CNM, HEPHY in Vienna and Charles University in Prague)
  - EMC issues: implication on power distribution network and module integration. Jointly with ITA
  - Optical fiber sensors for environmental and structural monitoring of the future trackers. Jointly with Spanish Aerospace Agency (INTA)





LHC/Upgrades, Santiago de Compostela University

LHCb Upgrade: USC activities (1)



UPGRADED VELO @ 40MHz Readout

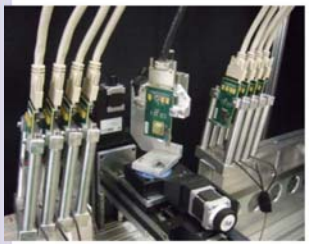
- Challenges: Data rates $\langle rate_{max} \rangle = 200MHz\ cm^{-2}$
  - $Irradiations_{max} = 5.10^{15}$ 1 MeV $n_{eq} cm^{-2}$
  - Low material budget
  - Improve excellent pv resolution (13μm)
- Two technologies:
  - Pixel detector: VELOPIX based on TimePix
    - 55 μm x 55 μm pixel size
    - CVD Diamond substrate
  - Micro-strip detector: minimum pitch 30 μm improved R-ϕ geometry

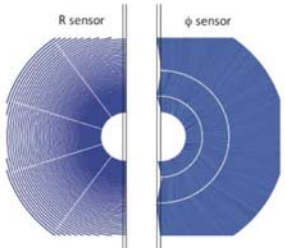
R&D ongoing at USC:

- Sensor options:
- Pixel: thinning and Tile construction
- Micro-strip: sensor design, prototyping and testing
- High-speed radiation hard cooper link (5Gbs)

I.Vila, vila@ifca.unican.es - RECFA/Spain meeting, 7th Oct Madrid 2011. 9

LHCb Upgrade: USC activities (2)



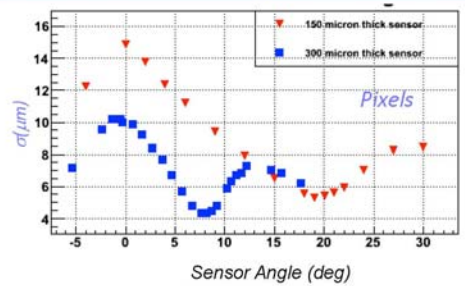


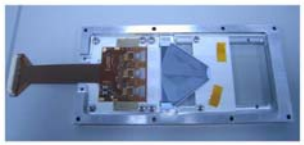
Micro-strip sensors being made at Hamamatsu

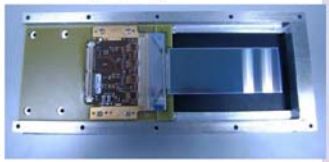
Test Beam TimePix Telescope

Results:

- 2011 JINST **6** P05002 doi: 10.1088/1748-0221/6/05/P05002
- NIMA53849, doi: 10.1016/j.nima.2011.09.021







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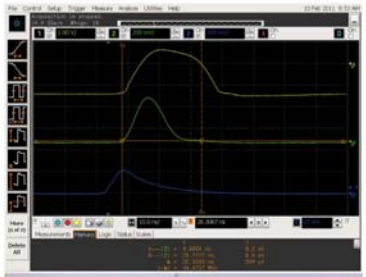
LHC/Upgrades, Barcelona and Ramón Llul Universities

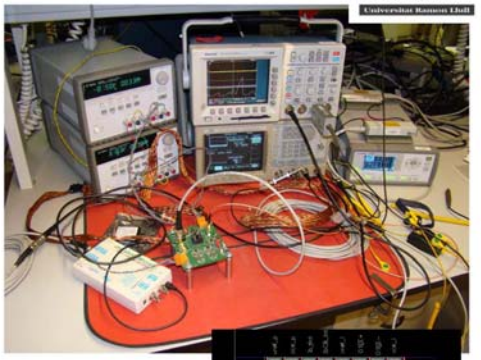
LHCb Upgrade: UB & URL activities (1)

- The (Calorimeter) FE-boards need to be replaced to accommodate the increase of full read-out from 1 to 40MHz (Phase II)
- R&D Plans for Analog front-end development (based on the SPD experience):
  - ASIC solution (UB) (jointly with LAL
  - COTS solution, embedded system (URL)
- Scint Fiber tracking with SiPM RO (UB)
- Synergies with gamma observatory CTA.

LHCb Upgrade: UB & URL activities(2)

COTS - clipping approach





ASIC dual channel subtraction