Experimental Particle Physics at CIEMAT

Progress Report

Restricted ECFA Meeting

March 29, 2003

Manuel Aguilar Benítez

CIEMAT

R & D Projects, Resources

Overview

- CIEMAT
- Overview of Research Projects
- Evolution of resources
- Present activities and responsibilities
    - High Energy Physics Experiments
    - Astroparticle Physics Experiments
    - Superconductivity
    - Support to other HEP Groups
- Summary

CIEMAT

Centro de Investigaciones Energéticas, MedioAmbientales y Tecnológicas)

Ministerio de Ciencia y Tecnología

Five Research Departments

- Nuclear Fission
- Fossil Fuels
- Renewable Energies
- Environmental Impact of Energy
- Fusion and Elementary Particles

And departments providing services and support to R&D projects:

- Mechanical and electronical workshops
- Engineering office
- Computer center

Total number of employees: 1150
(47% with University Degree)

Department of Fusion and Elementary Particles

R & D Projects:

- National Laboratory for Magnetic Fusion
- Material for Fusion
- Experimental High Energy Physics *(Marcos CERRADA)*
- Astroparticle Physics *(Javier BERDUGO)*
- Applied Superconductivity *(Luis GARCÍA TABARÉS)*
- Electronics and Automation Laboratory *(Carlos WILLMOTT)*
- Metrology of Ionizing Radiations

Department of Nuclear Fission

- FACET project (n-TOF) *(Enrique GONZÁLEZ)*

Overview of Research Activities

L3 & L3+Cosmics

CMS Collaboration with

IFCA-Cantabria
Univ. Oviedo
Univ. Autónoma de Madrid

AMS Collaboration with

CEDEX
IAC

FAST

n -TOF Collaboration with

CSIC-IFIC (Valencia)
Univ. Santiago de Compostela
Univ. Politécnica de Cataluña
Univ. Sevilla
Univ. Politécnica de Madrid

R & D in magnets for particle accelerators

Applied Superconductivity Group

Short summary of activities of CIEMAT HEP Group taking last RECFA meetings in Spain as a reference

RECFA 83	RECFA 92	RECFA 97	RECFA 03
HS Collaboration NA16, NA23, NA27 ARK-J 3 (LEP) (Preparing Technical Proposal)	L3 (LEP) Fixed Target Experiments NA36, WA-85, WA-94 RD5 and preparing LHC L.O.I (L3+1, CMS) TCF	L3 (LEP) CMS (LHC) Barrel Muon Link Alignment System VFCAL Calorimetry	HEP Experiments CMS (LHC) L3 & L3Cosmics FAST Astroparticle Phys Experiments AMS Other n-TOF

Short summary of human resources and evolution taking last RECFA meetings in Spain as a reference

RECFA 83	RECFA 92	RECFA 97	RECFA 03
Staff Fixed Term Fellows	7 Staff 3 Fixed Term 6 Fellows	7 Staff 6 Fixed Term 8 Fellows	14 Staff 6 Fixed Term 9 Fellows
OTAL: 18	TOTAL: 16	TOTAL: 21	TOTAL: 29
Technicians	1 Technical Engineer 4 Technicians	1 Technical Engineer 4 Technicians	2 Engineers 9 Technicians

hese numbers include only personnel in High Energy Physics and Astroparticle nysics projects.

Applied Superconductivity

- 2 Staff
- 1 Fixed Term
- 1 Fellow
- 1 Technical Engineer

Electronics and Automation Laboratory

- 8 Staff
- 4 Fixed Term
- 1 Fellow
- 15 Technicians

The L3 Experiment

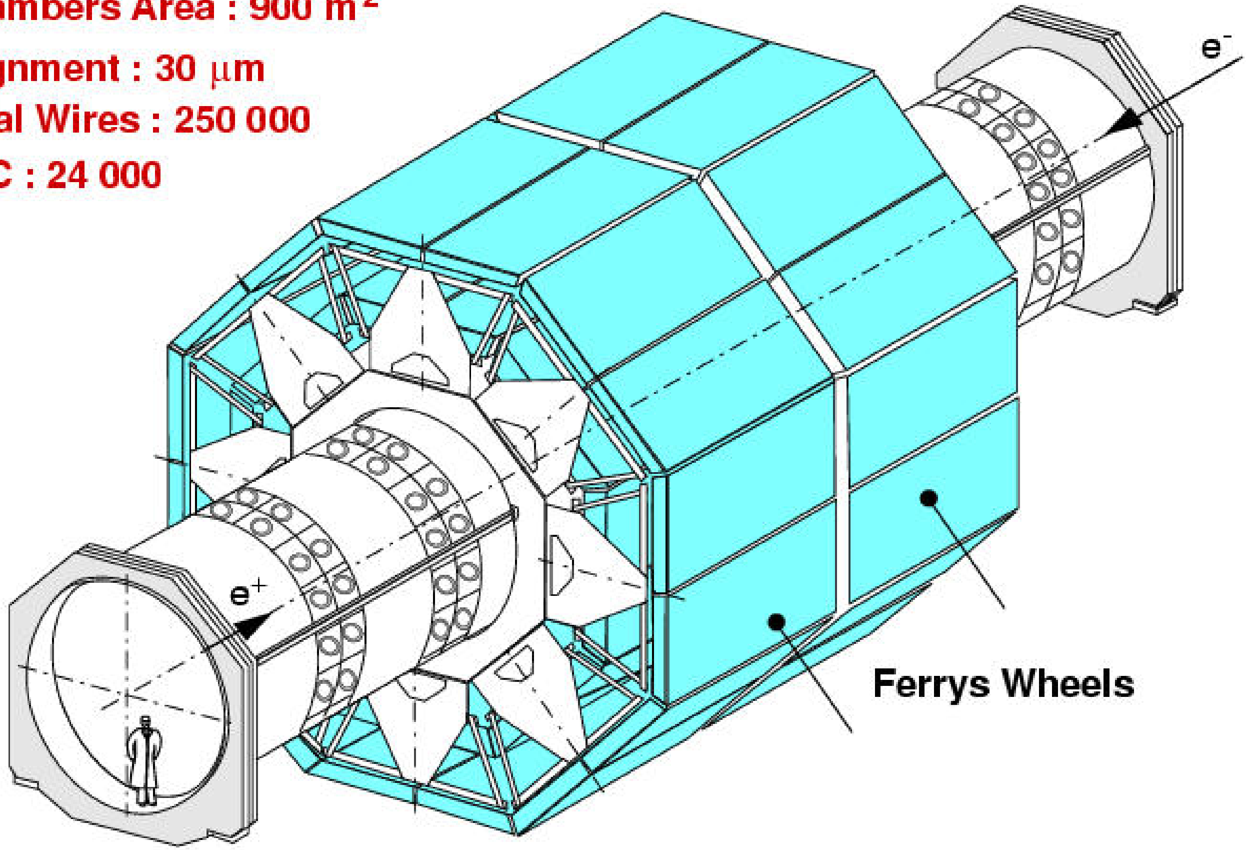
Construction of the L3 Muon Spectrometer

Chambers Area : 900 m^2

Alignment : 30 μm

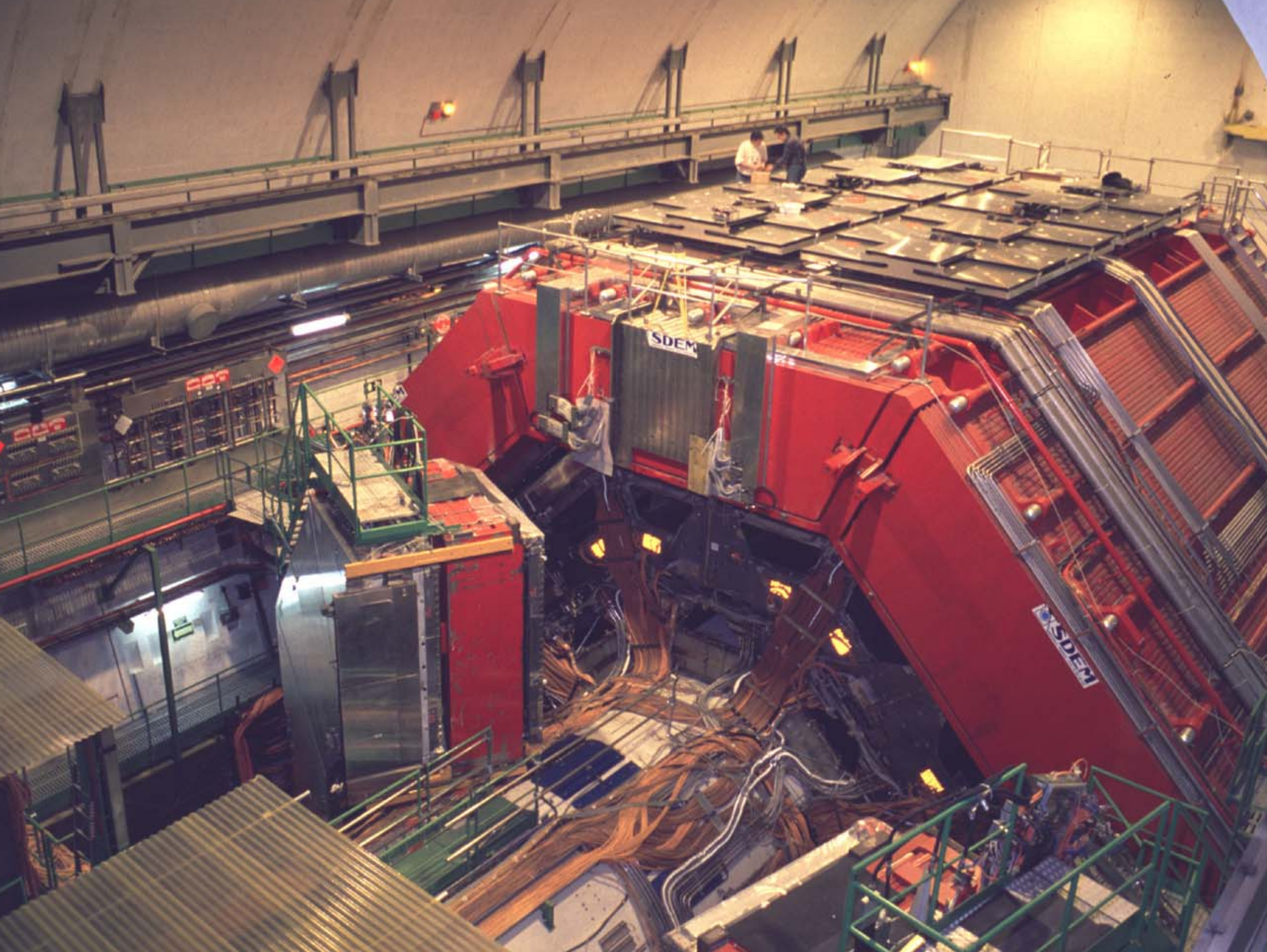
Total Wires : 250 000

TDC : 24 000

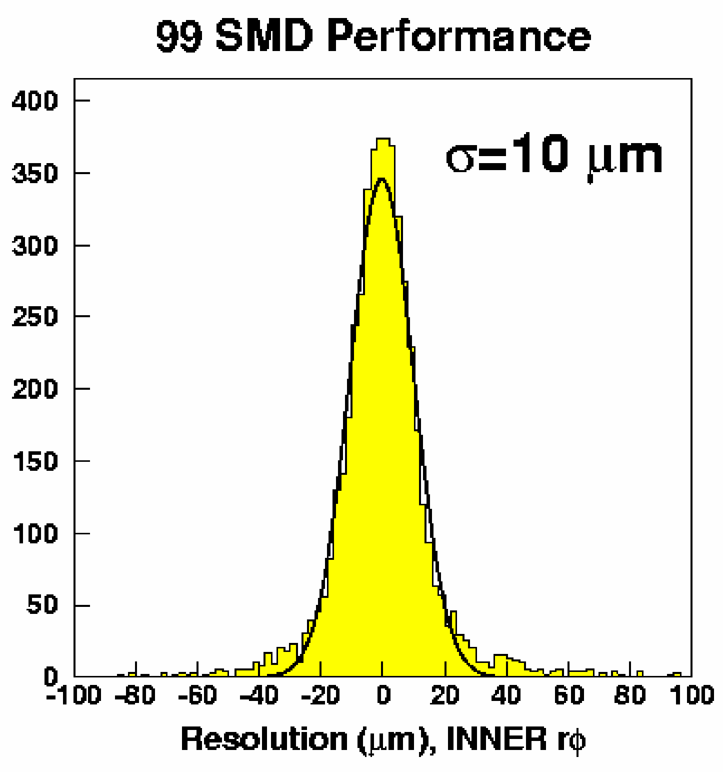


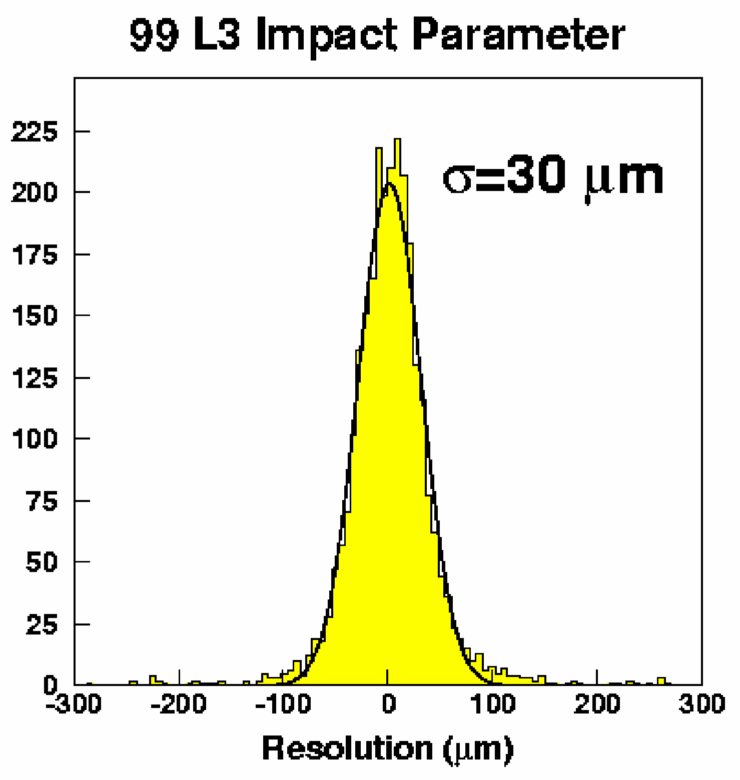
Important contribution from CIEMAT to the Octant Modules, Drift Muon Chamber production, Alignment and Monitoring Systems.

Total Funding: 8 MCHF


SDEM
SDEM

Alignment of the SMD (Silicon Microvertex Detector)





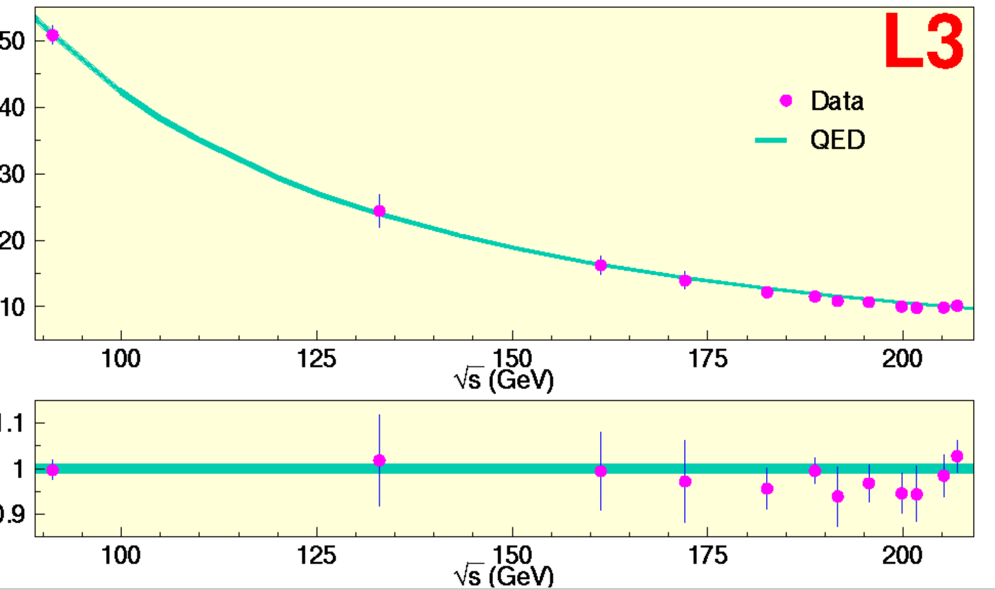
- CIEMAT responsibility since 1994
- Correct alignment of the SMD is fundamental for TEC chamber calibration and for the b quark event reconstruction (b-tagging).

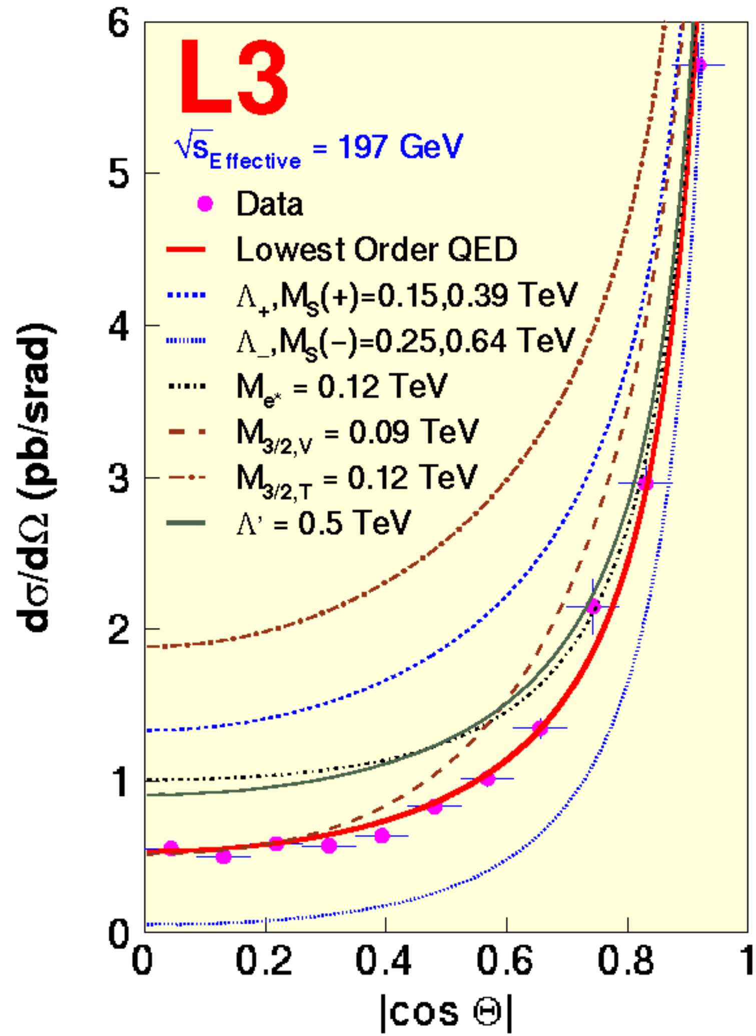
ajor CIEMAT Contributions during the Physics Analysis Phas

- ✓ Electroweak Physics results:
  - Z lineshape
  - Measurement of τ Polarization
  - Heavy Flavour Physics (Coordination of L3 WG)
- ✓ Neutral Boson Pair production (Coordination of L3 WG)
- ✓ Higgs Physics (Coordination of L3 WG)
- ✓ Anomalous Boson Couplings ($W^{\pm}$, Z, γ, H)
- ✓ Searches Beyond the Standard Model (QED Tests, Compositeness)
- ✓ Coordination of L3 Analysis from 2001 and L3 Contact Person in 2002 (J.Alcaraz)

LEP2 Physics

$e^+ e^- \rightarrow n\gamma$ $(n \geq 2)$

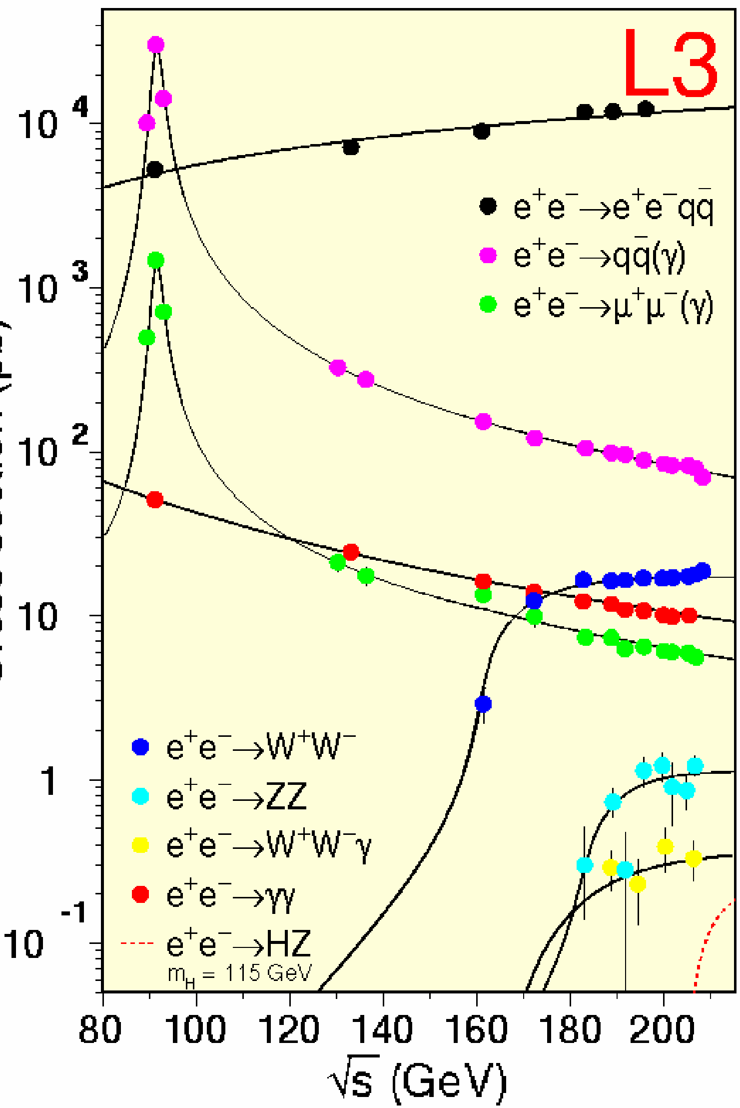


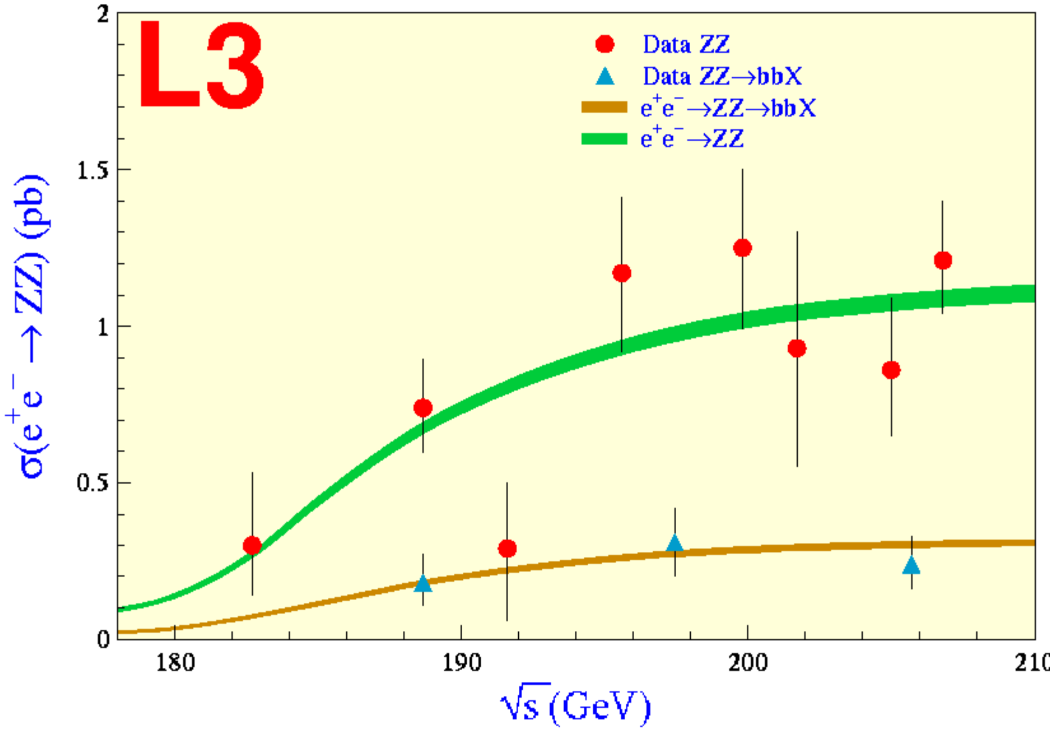


QED tests at very high energies

The responsability of this analysis was assigned to the L3 CIEMAT group

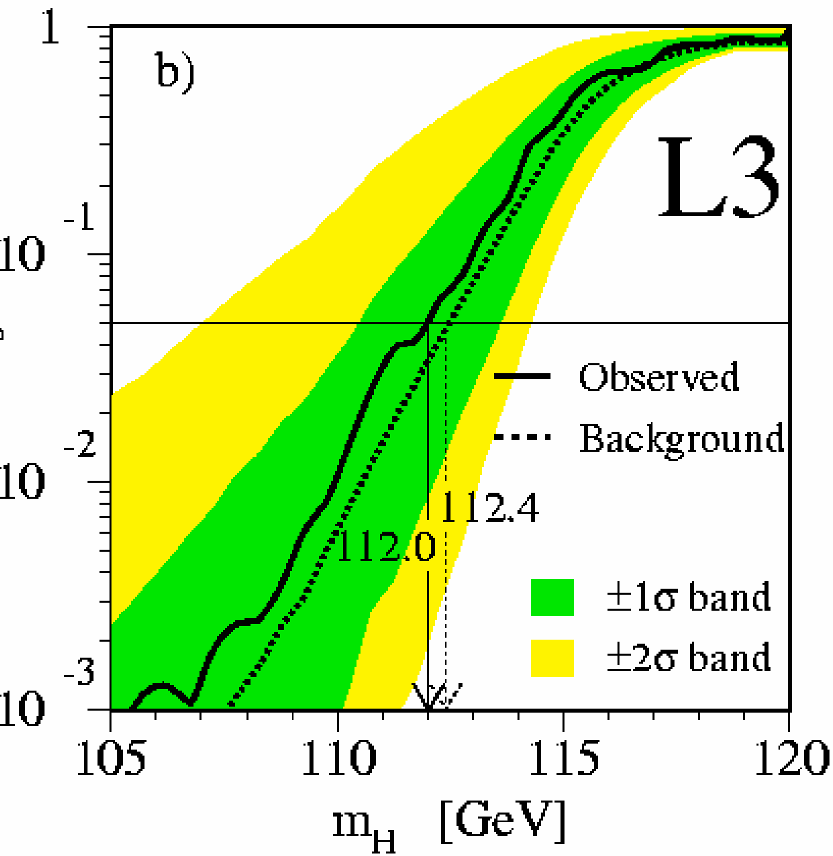
LEP2 Physics





- A member of the CIEMAT group has been cordinating the L3 working group studying ZZ production.
- Anomalous couplings (search for new physics beyond the Standard Model)

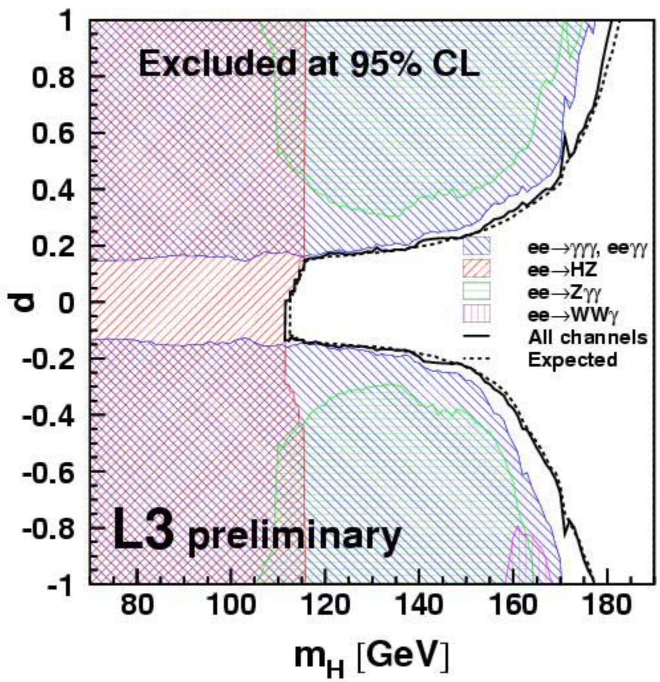
LEP2 Physics

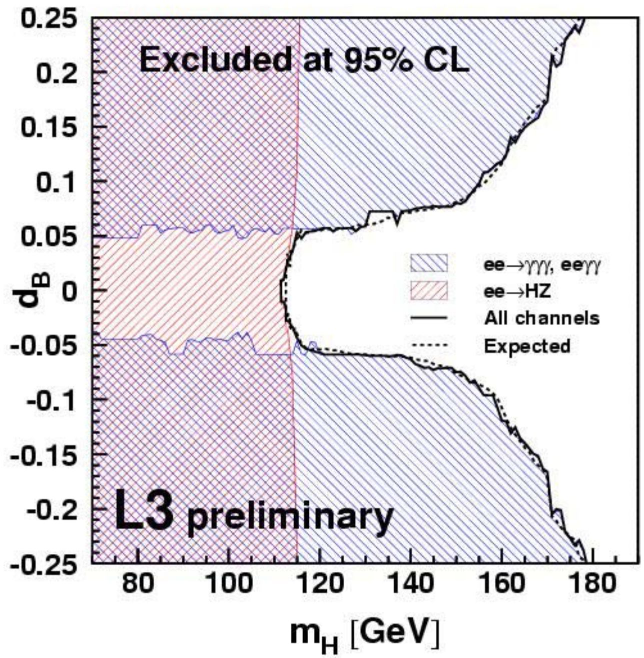


Standard Model Higgs search

- Highest center of mass energies wer reached in 2000: 209 GeV.
- Final L3 analysis: $M_{Higgs} \geq 112$ GeV
- In the framework of the Standard Model, $M_{Higgs} \leq 200$ GeV (95% C.L.)
- A member of CIEMAT was the coordinator of the L3 Higgs working group during 2001.

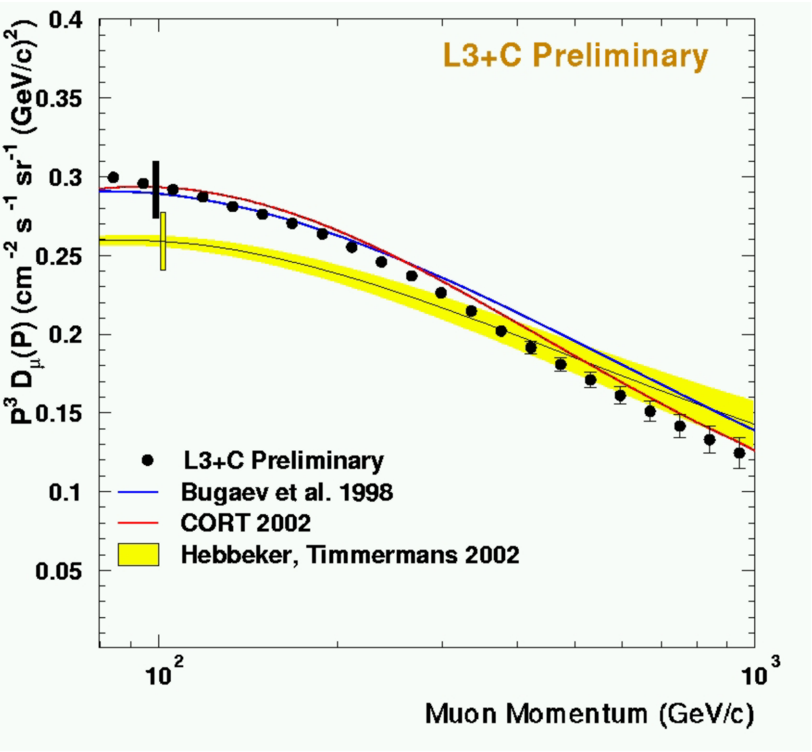
LEP2 Physics

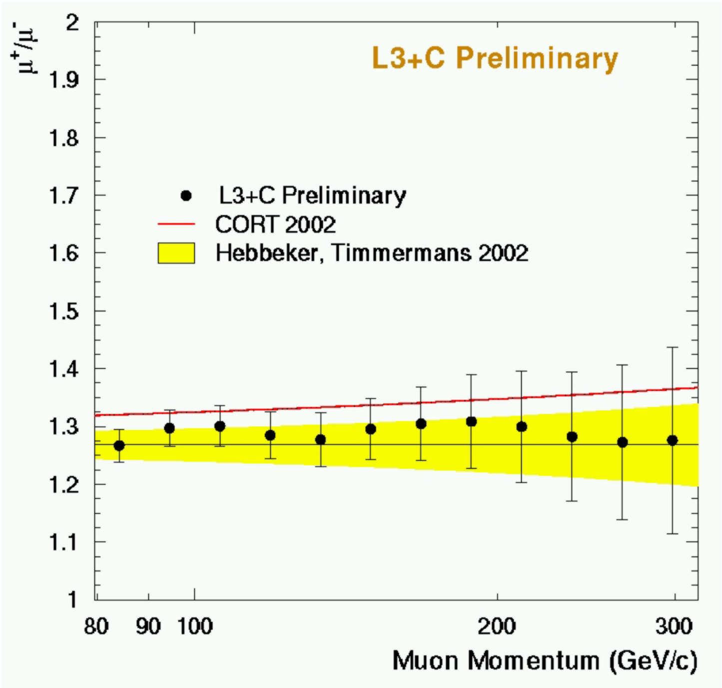




L3 data largely constrain the Higgs anomalous couplings in the region $M_{Higgs} < 160$ GeV

L3 Cosmics



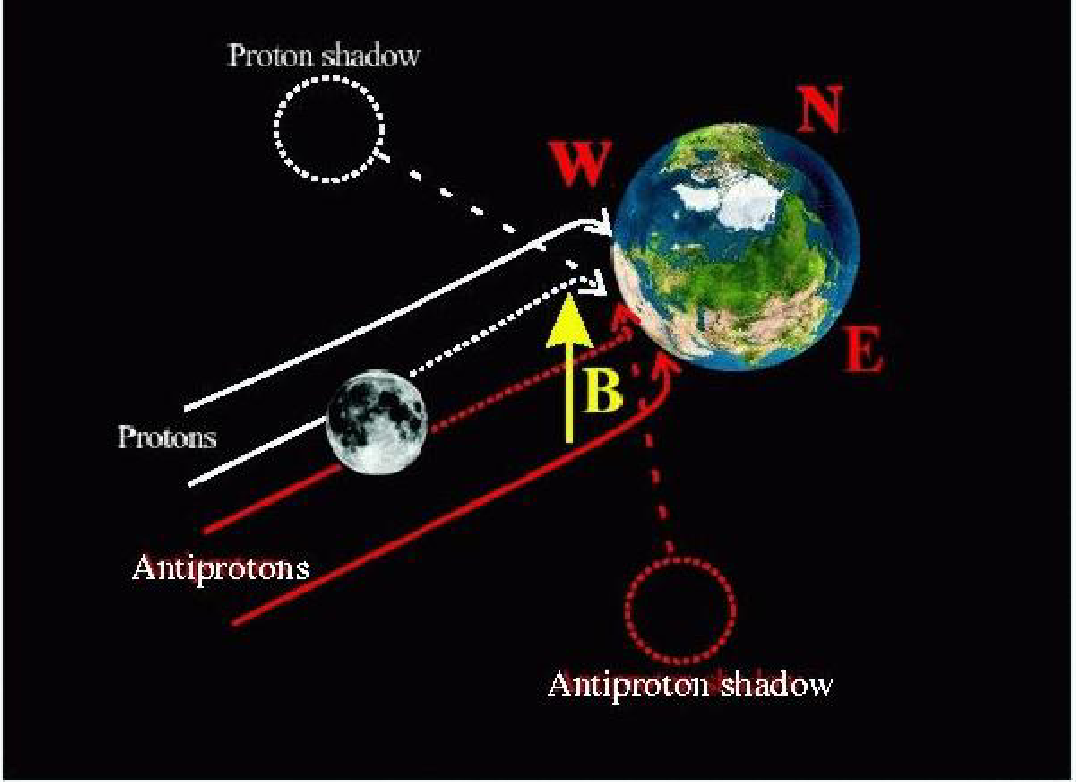


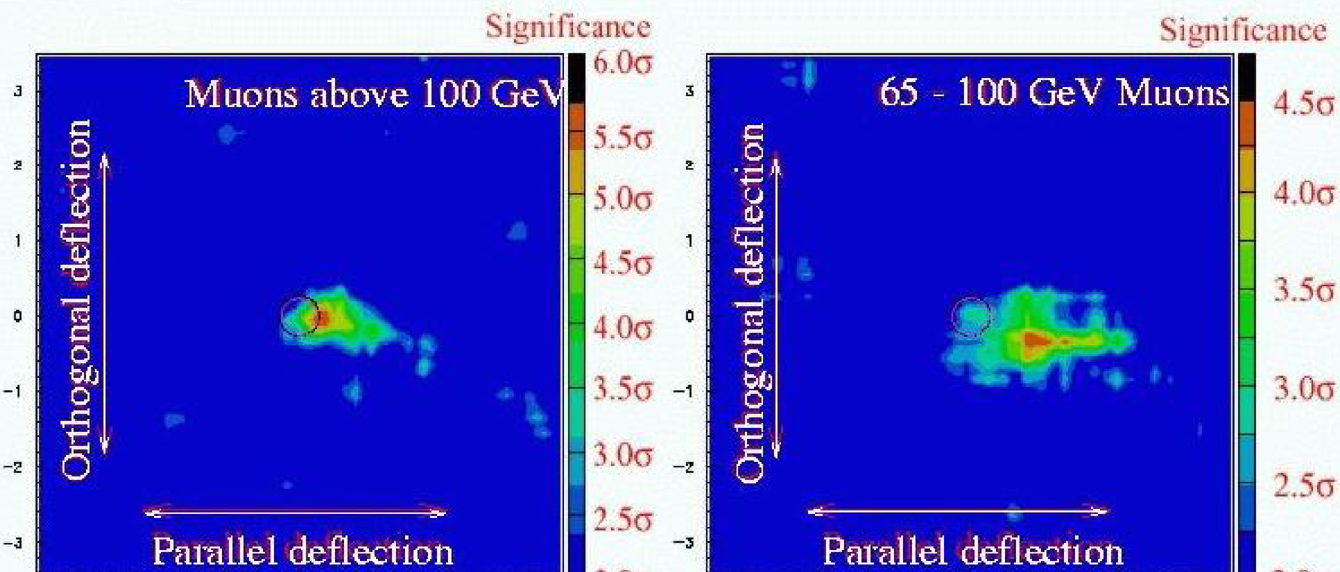
Comparison of the spectrum of cosmic muon momenta, as measured in L3, with several models.

Positive to negative cosmic muon ratio, as measured in L3, and its comparison with several models.

L3 Cosmics

The moon shadow effect





CIEMAT activity in L3 is essentially finished today. There is only a small effort going on to complete and publish final results in some analyses.

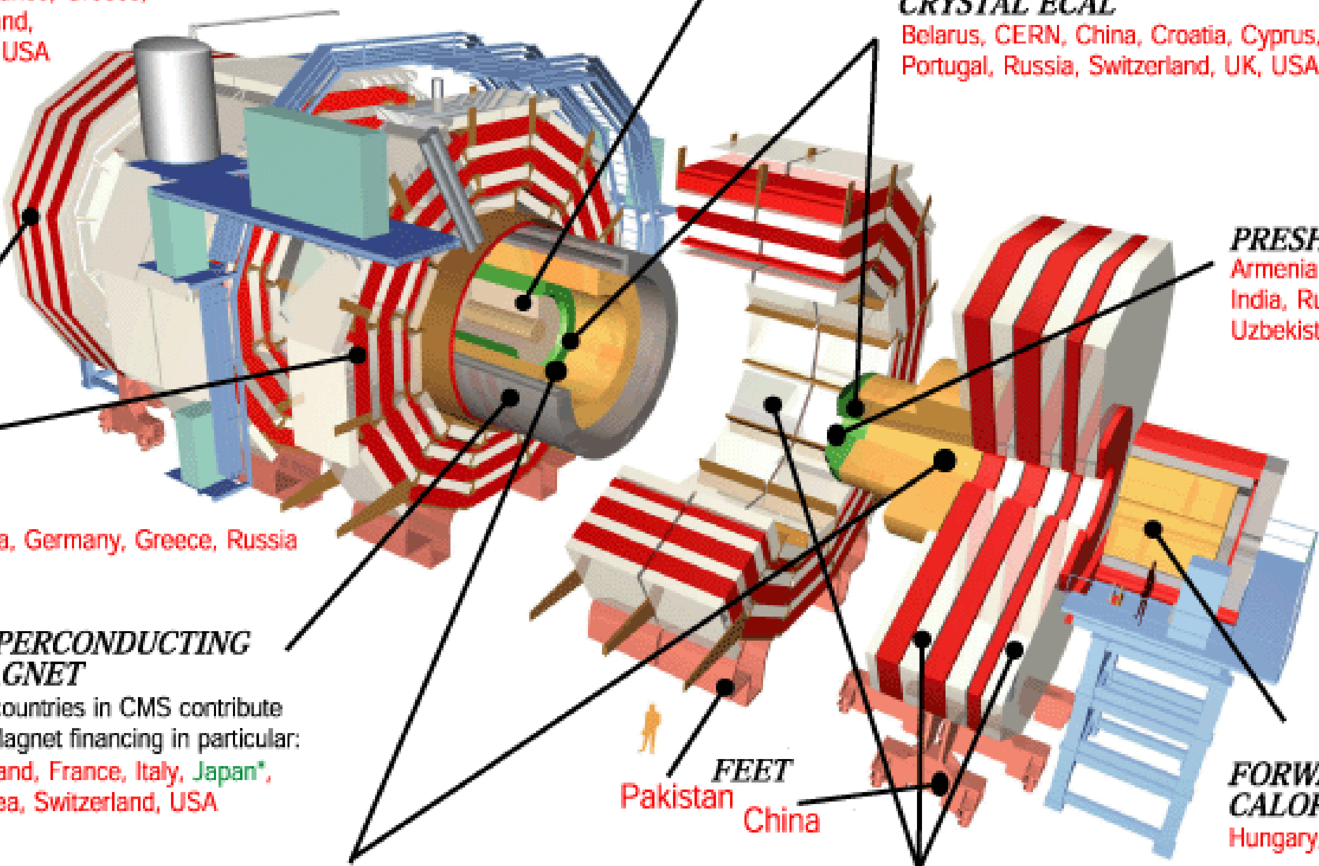
A total of 17 PHD thesis have been presented up to now in CIEMATin connection with the L3 experiment (another one will be presented in july 2003).

In average 10 presentations of L3 physics results in Internatiional Conferences and Workshops have been made every year by CIEMAT group members.

The CMS Experiment

The CMS Detector

31 Nations, 150 Institutions, 1870 Scientists



al weight	:	12500 T
erall diameter	:	15.0 m
erall length	:	21.5 m

SUMMARY OF CIEMAT RESPONSIBILITIES

- The Barrel Muon Detector

  Drift Tube Muon Chambers

  Design and production of 70 chambers out of a total of 250
  Chamber readout system electronics: design and fabrication

- CMS Alignment

  The "Link System"

  Design, construction and installation of the Link System
  (in collaboration with Santander group)

TOTAL FUNDING CMS SPAIN

CIEMAT 90%
Real Cost: ~7 MEuros
(1995-2005)

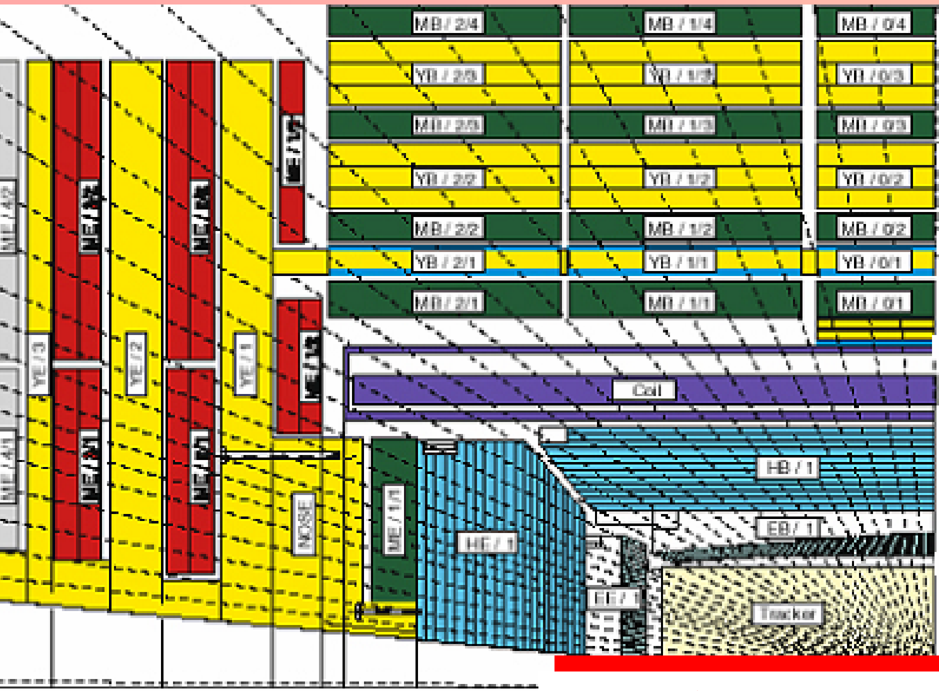
CORE money in MOU

Common Projects	1,89 MCHF
Barrel Muon	3,06 MCHF
Alignment System	1,06 MCHF
TOTAL	6,00 MCHF

Cost to Completion

Common Projects	0,35 MCHF
Barrel Muon	0,70 MCHF
Alignment System	0,30 MCHF
TOTAL	1,35 MCHF

The Muon System



System Conditions

Barrel $\eta < 1.3$

Particle Rates < 10 Hz/cm^2

Low Magnetic Field

Endcap $0.9 < \eta < 2.4$

Particle Rates 100-1000 Hz/cm^2

Magnetic Field

Uniform axial > 3 T in ME1/1

Highly non-uniform radial field up to 1T in ME1/2

Muon Detector Requirements

- Muon identification
- Muon momentum measurement
  - Charge assignment correct to 99% confidence level up to 7 TeV
  - Momentum resolution

Stand alone	$\delta p_T/p_T$ = 8 - 15%	at p_T = 10 GeV
	$\delta p_T/p_T$ = 20 - 40%	at p_T = 1 TeV
Global	$\delta p_T/p_T$ = 1 - 1.5%	at p_T = 10 GeV
	$\delta p_T/p_T$ = 6 - 17%	at p_T = 1 TeV

- Muon Trigger
  - Unambiguous BX identification
  - Trigger single and multimuon with well defined p_T thresholds few GeV to 100 GeV

CMS Muon Detectors - Requirements

Resolution (per station)

Position RΦ : 100 μm

Z : 150 μm

Angle: 1 mrad

BX identification Efficiency

>98% per station

Drift Tubes - DT

Spatial resolution (Φ) (per station)

75 μm ME1/1 and ME1/2

150 μm for the others

(In trigger < 2mm)

Correct BX identification

> 92% per chamber (→ 99% global)

Trigger Track Efficiency >99 % per chambe

Cathode Strip Chambers - CSC

BARREL

ENDCA

Resistive Plate Chambers - RPC

(Dedicated Trigger Detector)

- Good timing : Resolution < 3ns (RMS), 98% within a 20ns window
- Good Rate capability
- Low cluster size
- High efficiency > 90% per chamber (→ 95% global)
- rΦ resolution ~ 1cm

The barrel muon detector

- 5 wheels

- Each with 50 muon stations located in the pockets of the iron magnet return yoke.

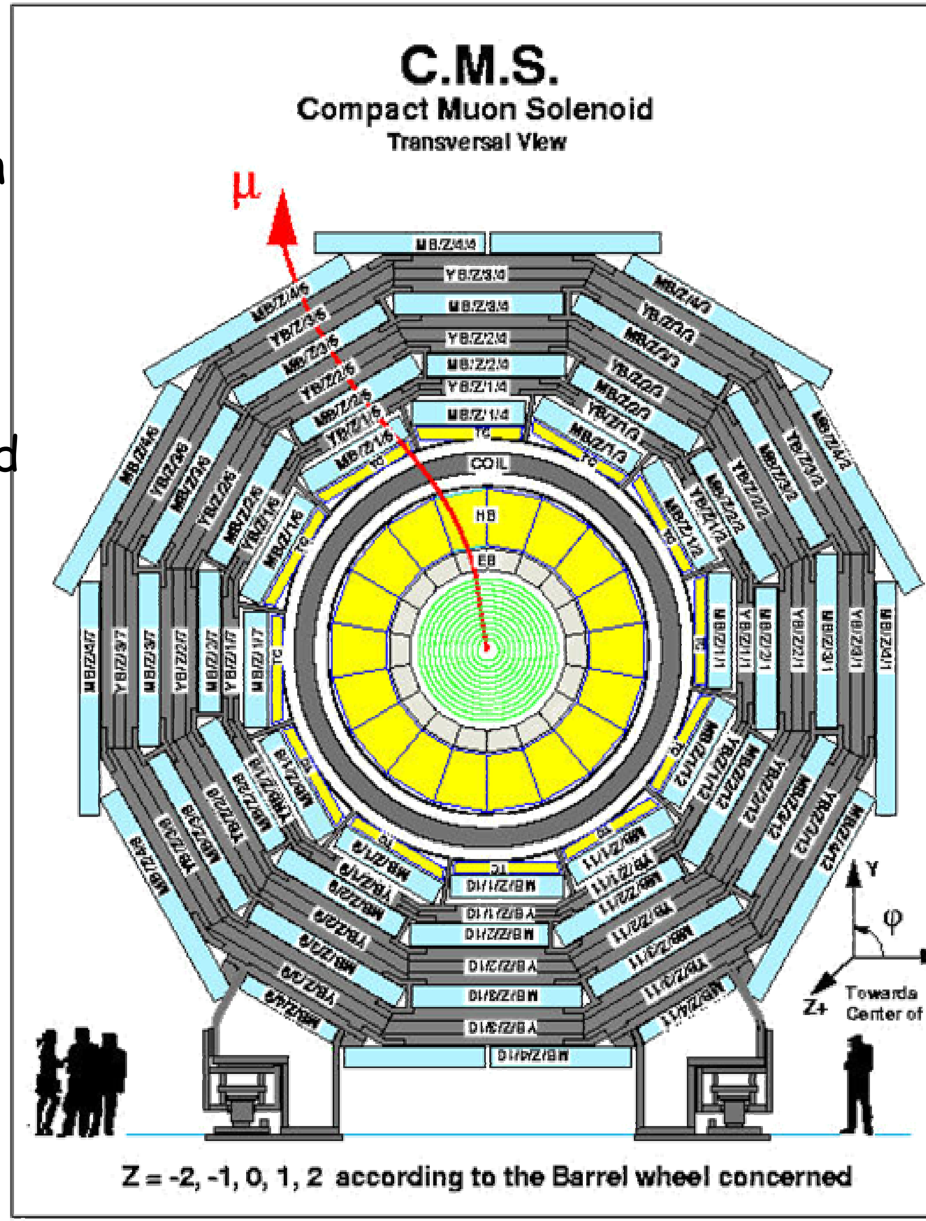
- 4 Layers: MB1,MB2,MB3,MB4 and each station is made by
  1 DT and 2 RPCs on MB1,MB2, and
  1 DT and 1 RPC on MB3,MB4

- The DT chambers use the Drift Tube technology.

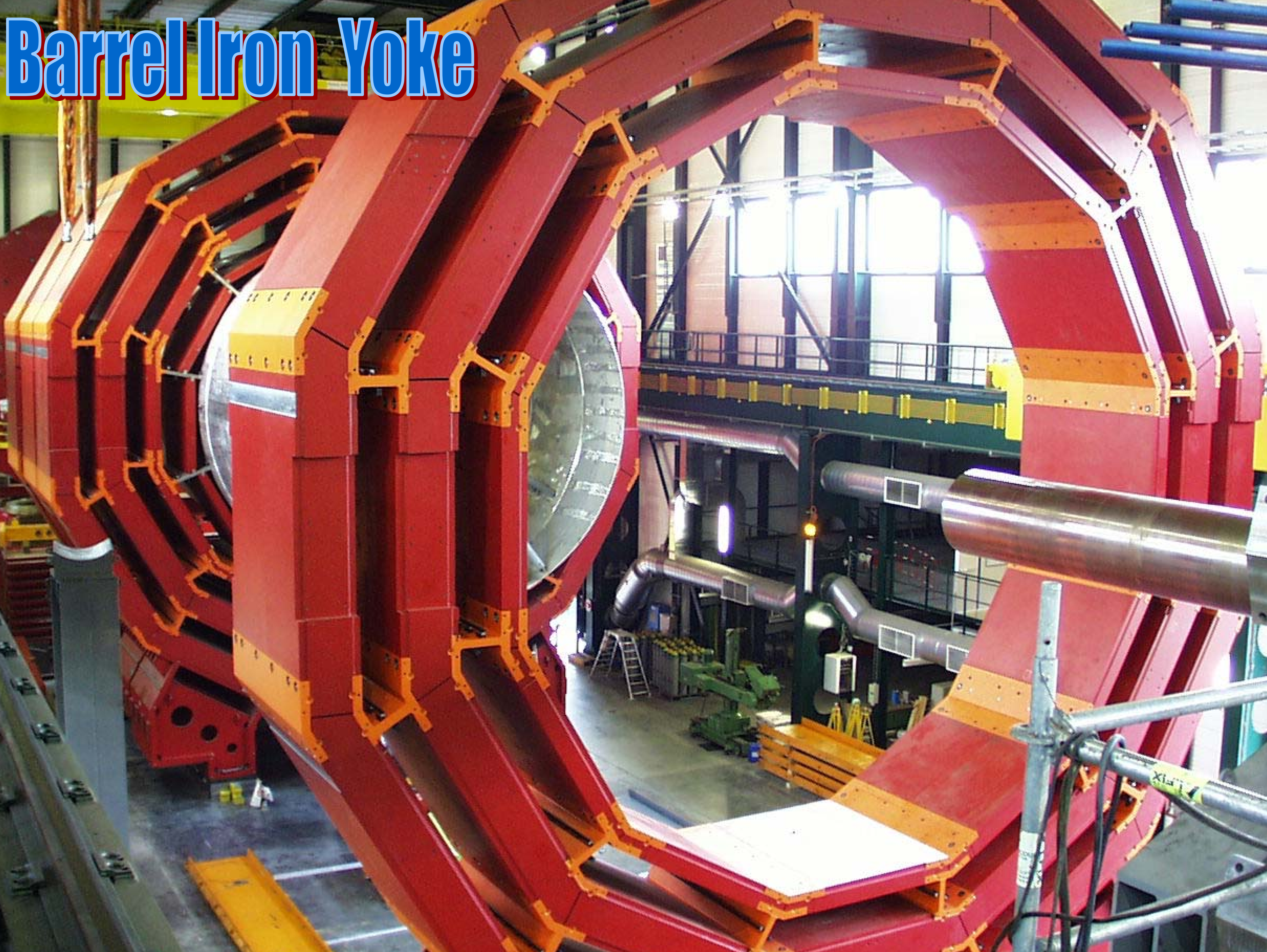
  - *Measurement of muon trajectory*
  - *Trigger and muon identification*

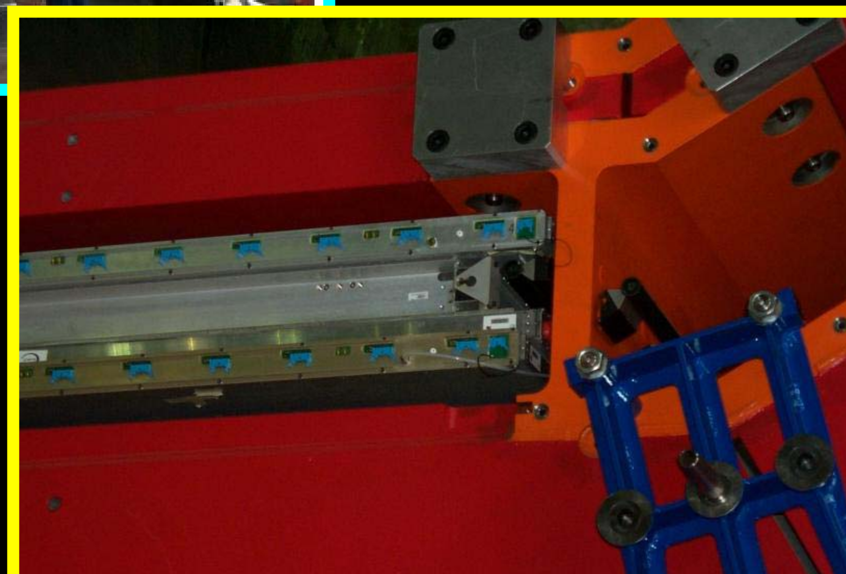
  The RPCs provide a complementary trigger system.

- The CIEMAT responsibility is to build 25% of the DT chambers.



Barrel Iron Yoke

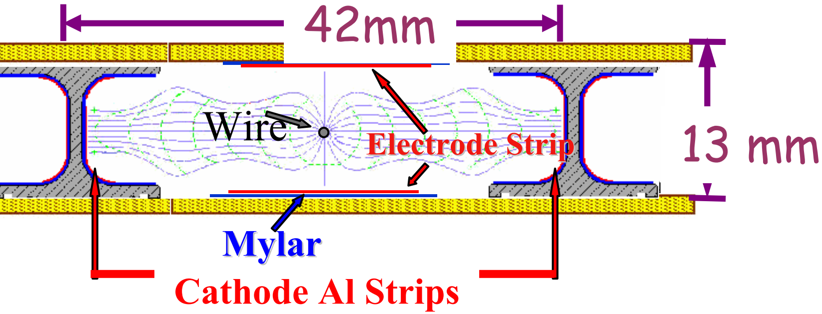




irst MB2 CIEMAT Chamber used to test insertion in the Yoke

August 2002

Drift Cell



GAS: Ar/CO_2 (85/15)

HV:

Wires	3600 V
Strips	1800 V
I-beams	-1200 V

max: < 400 ns

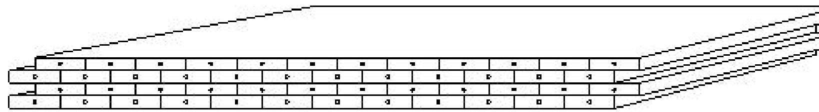
rift Velocity : ~ 55µm/ns

ingle Wire
esolution : < 300 µm

100 µm Φ
150 µm Θ

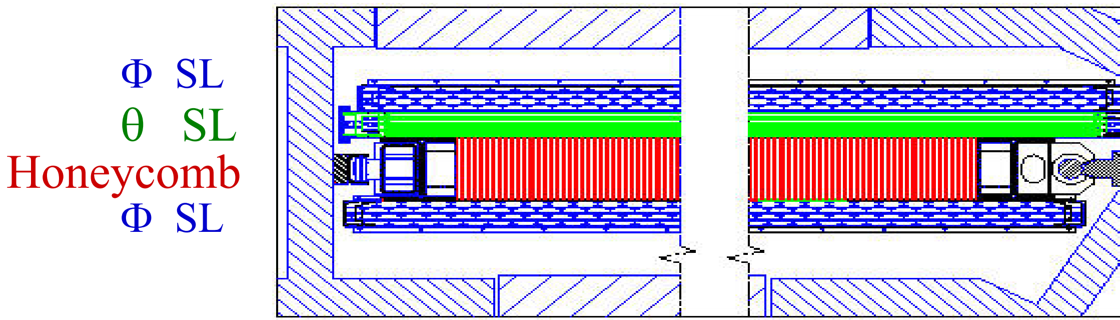
Drift Tube Chamber

4 Layers = 1 *Superlayer* (SL)



Independent Subunit

(Gas tightness, HV, Front End)



250 Chambers
172200 Anode Channels

CMS Barrel Muon Chamber organization

DT Chamber sharing

4 Chamber Production Centers

Aachen (RWTH)	60MB1 + 10 MB4
CIEMAT	60MB2 + 10 MB4
Legnaro (Padova + Bologna)	60MB3 + 10 MB4
Torino	40MB4

Institutes preparing chamber parts

Dubna		Plates with electrodes (strips)
Protvino		I-beam cathodes
IHEP (Beijing)		HVBoards and cables
CIEMAT	is responsible of	Readout Boards
Padova	is responsible of	FE and Trigger Electronics
Aachen	is responsible of	Gas and Cooling chamber services

Alignment system

CERN	Barrel Muon
USA	Endcap Muon
CIEMAT-Santander	Link

Chamber mass production at CIEMAT

Activity coordinated by Luciano Romero

3 assembly tables to build 3 superlayers in parallel equipped with
automatic glue dispenser and
a wire position measurement system (based on a CCD camera)

1 additional table to glue SL's to Honeycomb panel (chamber assembly table)

goal : produce a chamber every 2 weeks

Additional tools:

- ✓ 3 I beam layer gluing tools
- ✓ 1 automatic wire crimping machine
- ✓ 1 wire tension measurement system
- ✓ plates and I beam stores, transport tools, auxiliary tables, ...

All infrastructure ready to go in 2000


Mesa

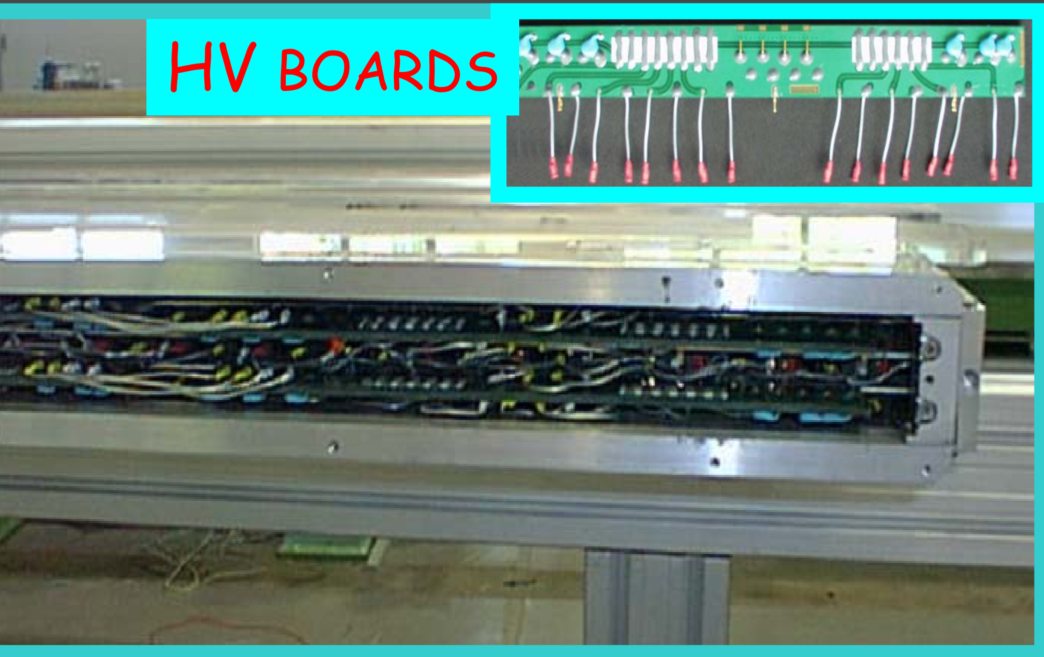



Main components needed during mechanical assembly of a SL

- Plates with strip electrodes
- Cathode I beams
- Wires and wire fixation pieces
- Corner blocks and frames

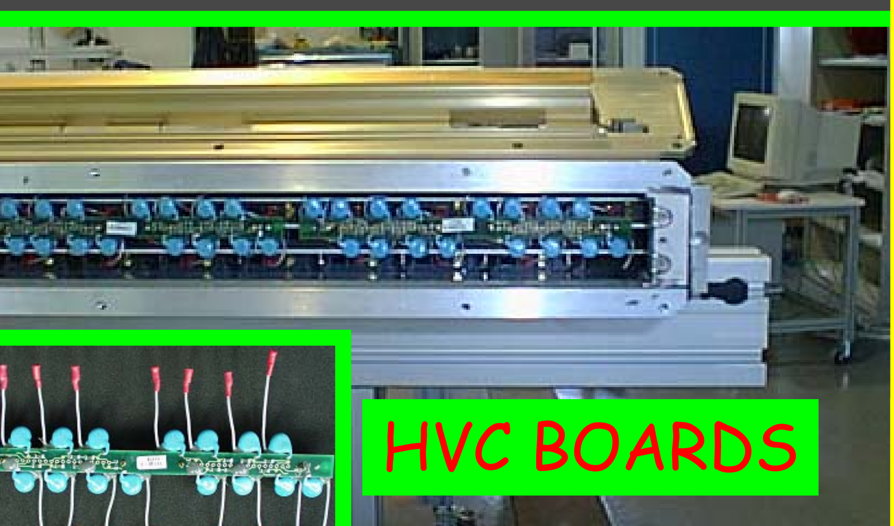
Machining of chamber frames
at CIEMAT mechanical workshops

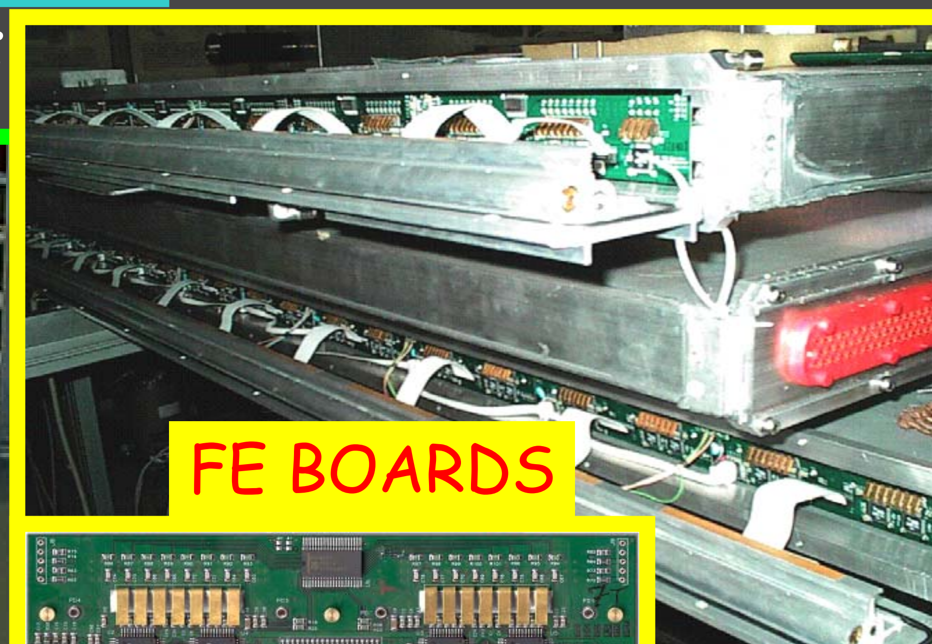
ELECTRONICS INSIDE SL GAS VOLUME



HV SIDE

FE SIDE



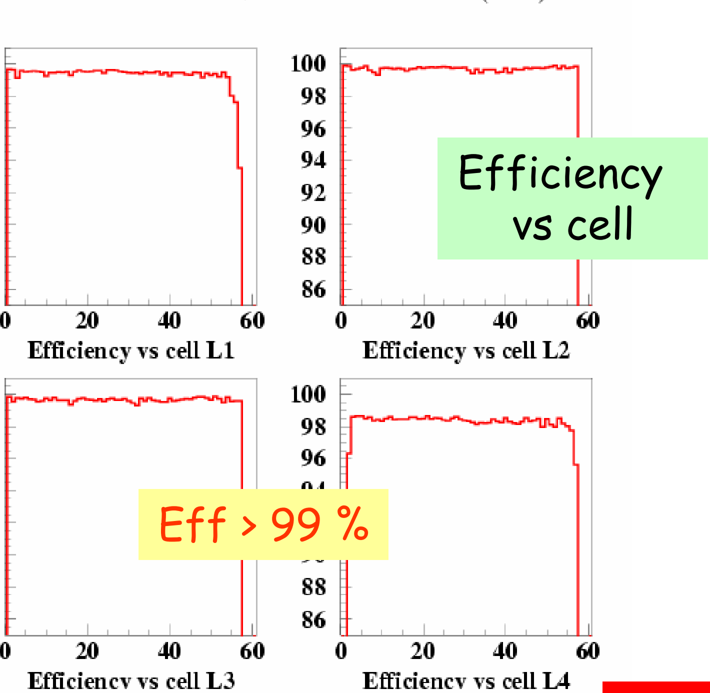


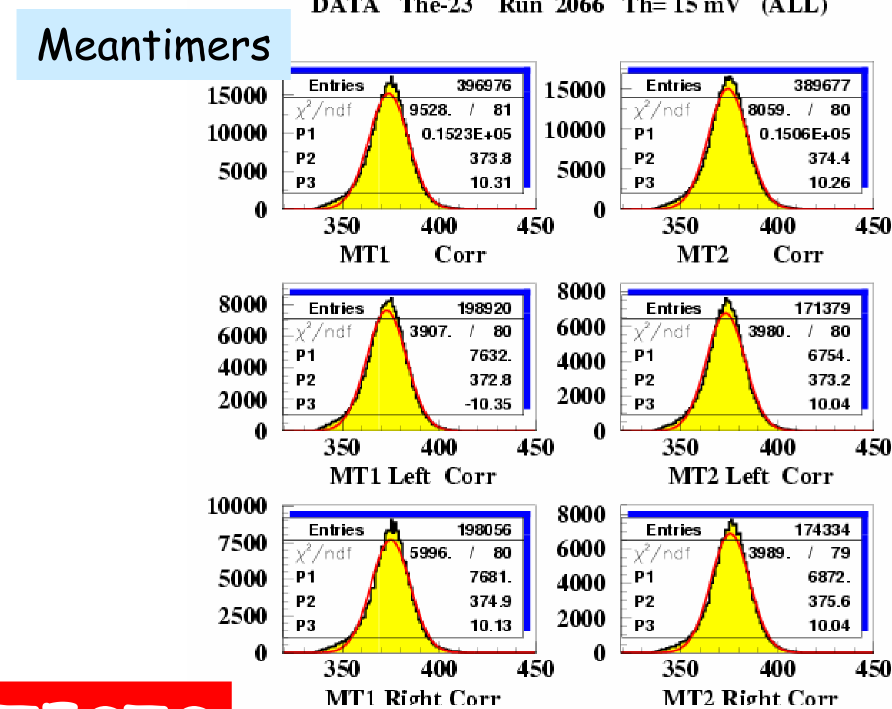
Chamber Testing at CIEMAT

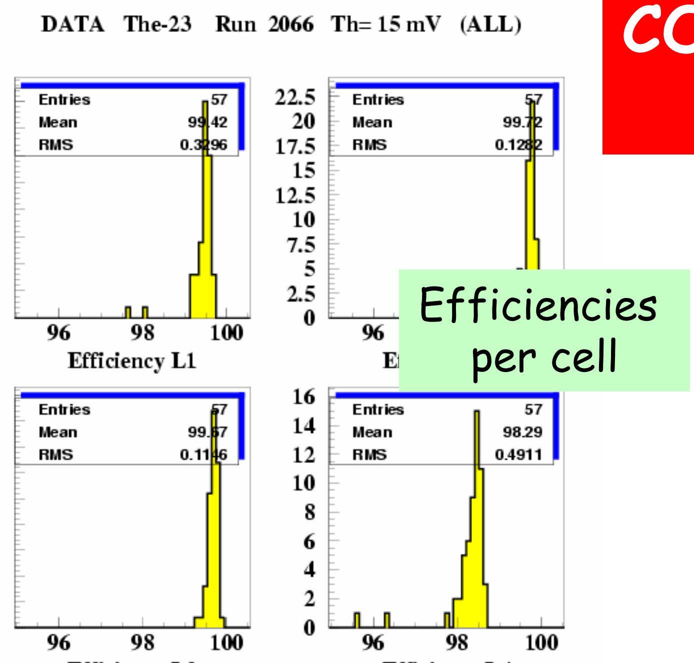
Activity coordinated by Mary-Cruz Fouz

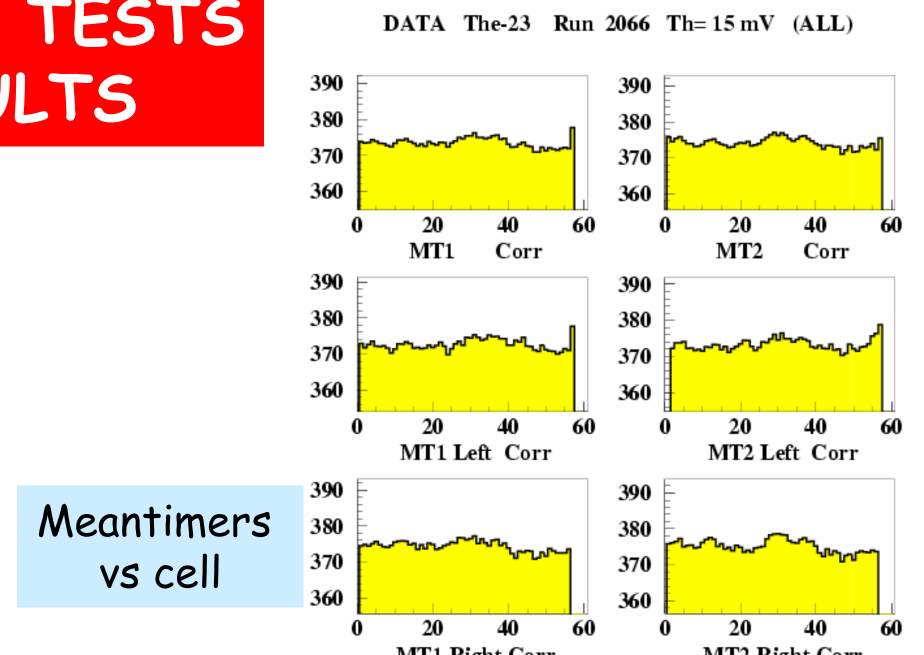
- Gas Tightness: Overpressure test performed & time constant measured.
- HV Test in air: HV at 4000/ 2000/ -2000 V for wires/ strips/ I-beams .
- HV Test in gas: HV at 3600/ 1800/ -1400 . Record disconnected cells, with info on whether it is wire or cathode (right-left).
- Cosmic Data: Data taken at HV= 3600/ 1800/ -1200 (sometimes –1400) V.
  Info recorded: ➔ TDC spectrum for each cell.
  ➔ Mean Timers right-left (every cell, all together
  ➔ Efficiency per cell.
- Noise: Measured at HV = 3600/ 1800/ -1200 V & Thresholds 15 (sometimes also 50, 95) mV. Info recorded: ➔ noise/cell & mean value for each plan
  ➔ # of cells with noise > 250, 500, 1000 Hz.

COSMIC TESTS RESULTS



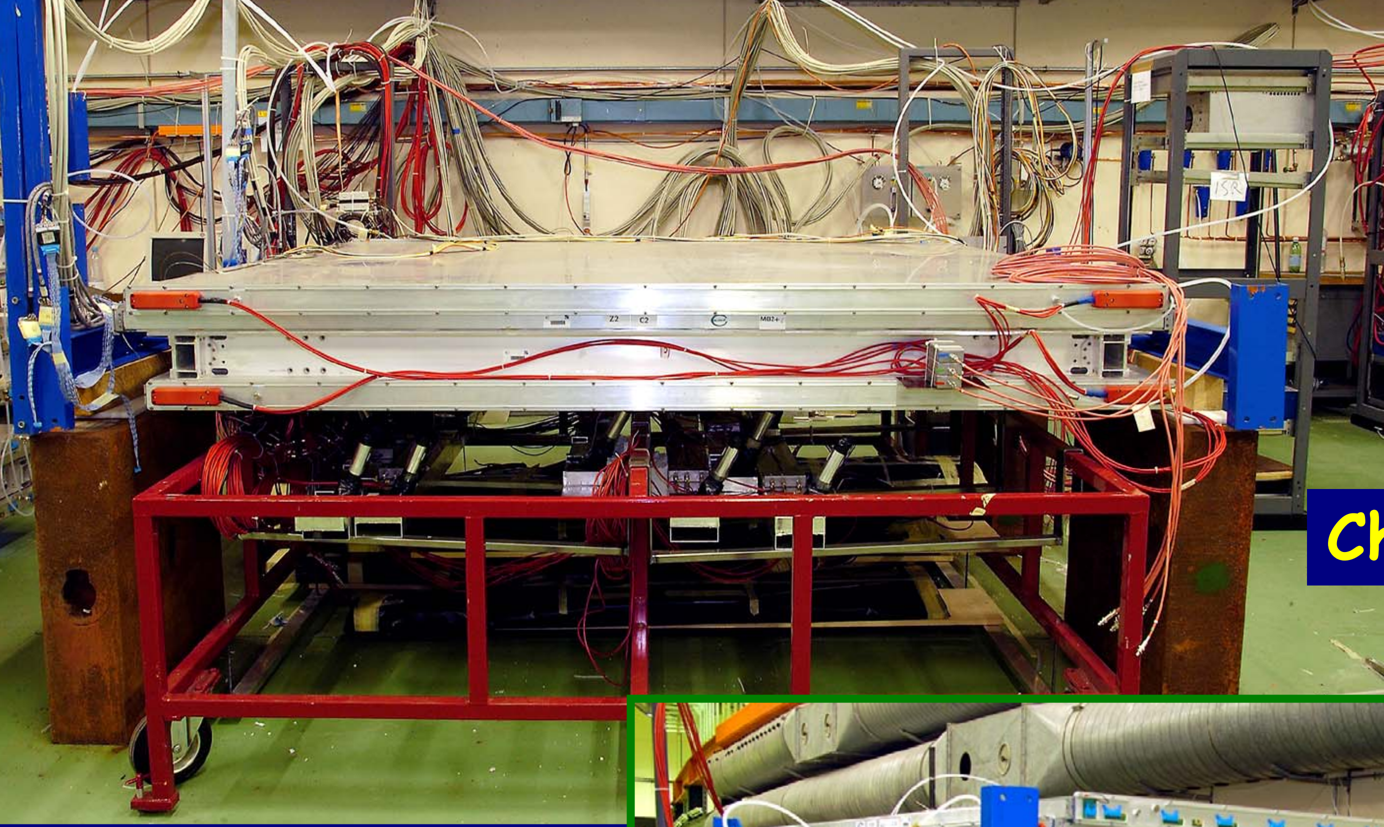






Last shipment of chambers
from CIEMAT to CERN

March 2003

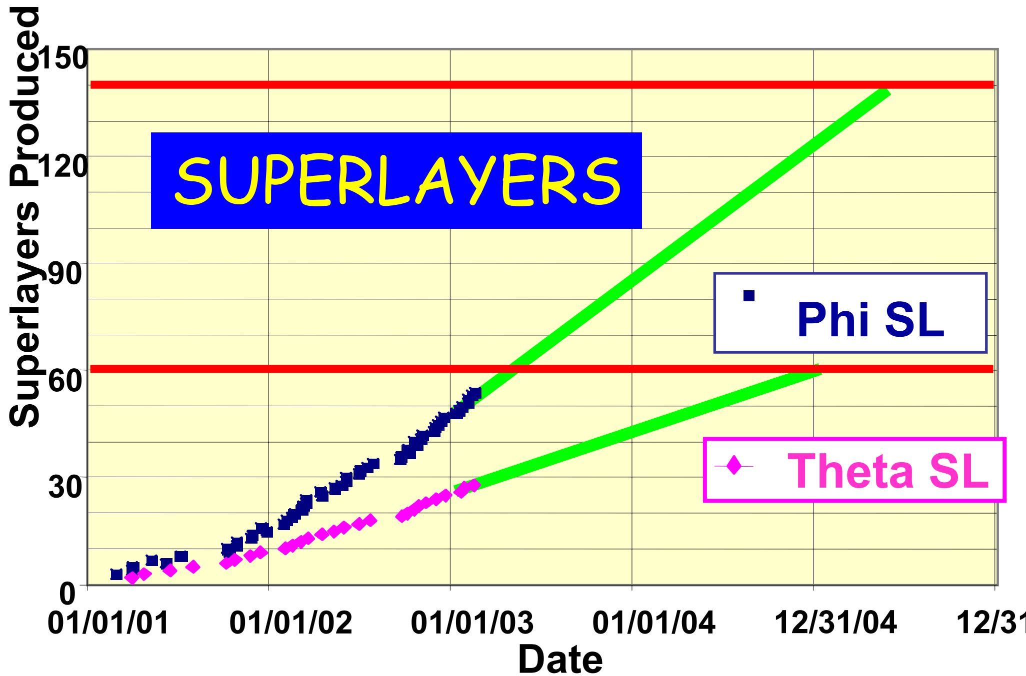


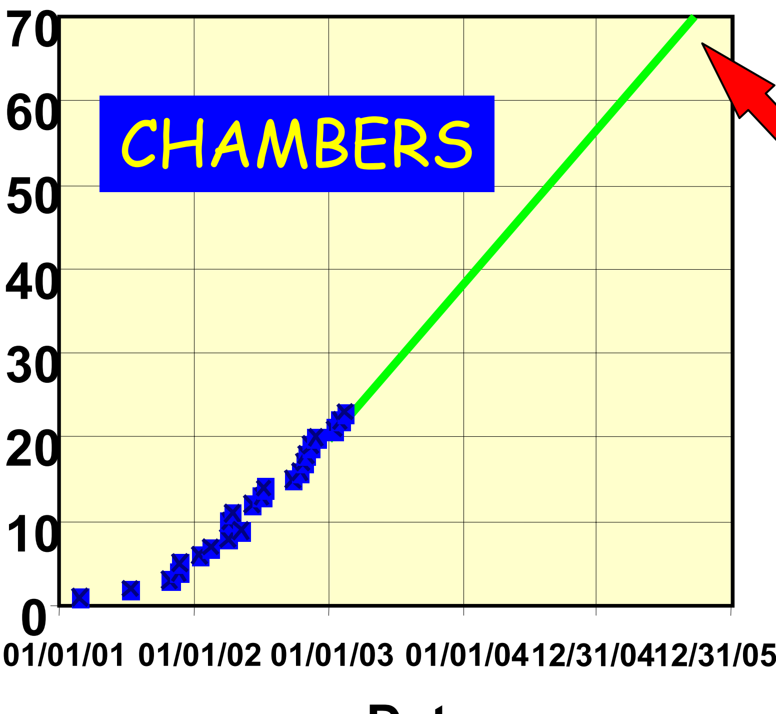
Chamber Testin

ISR hall at CERN

Chamber Storage

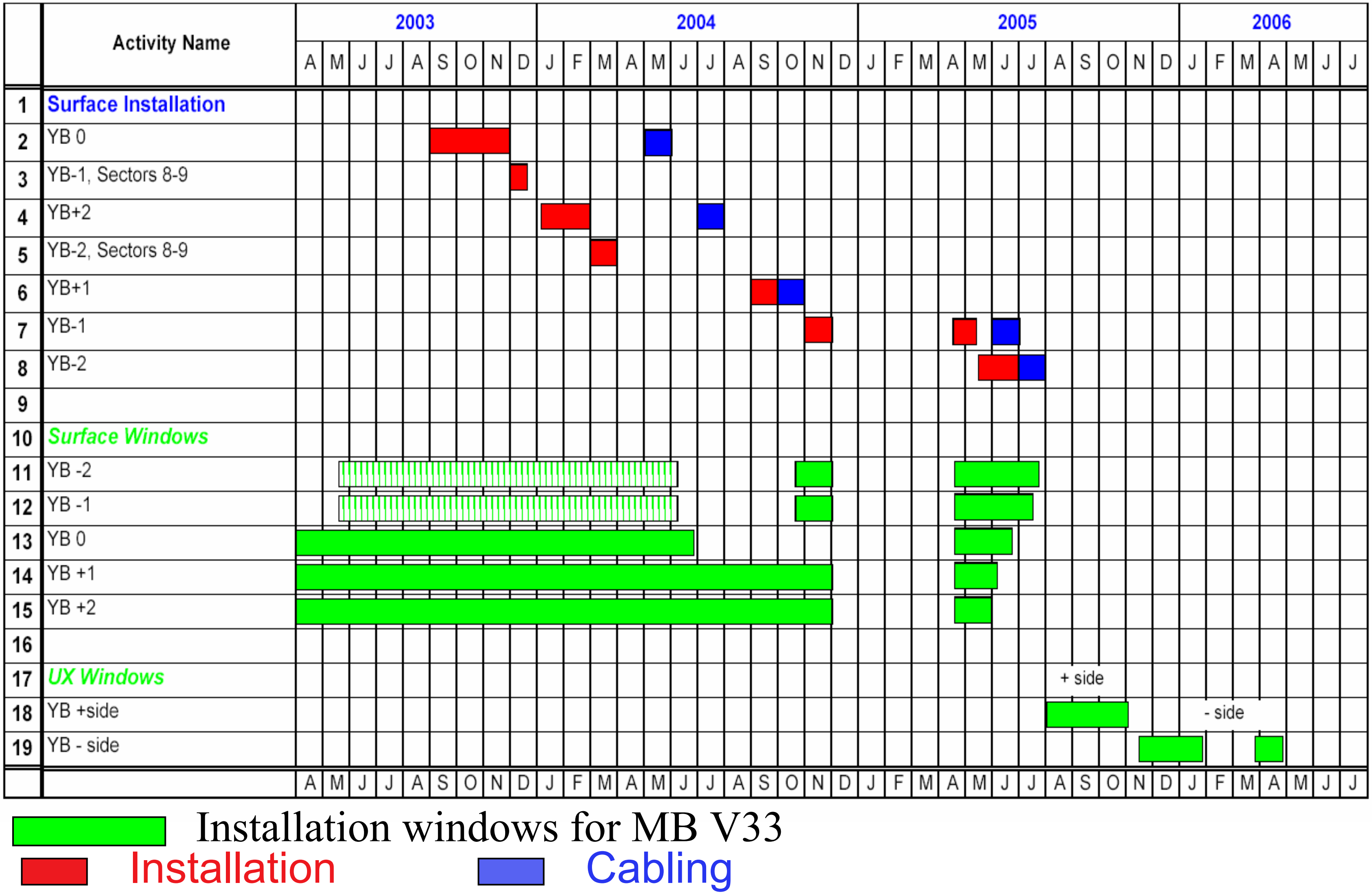
CIEMAT Chamber Production Summary



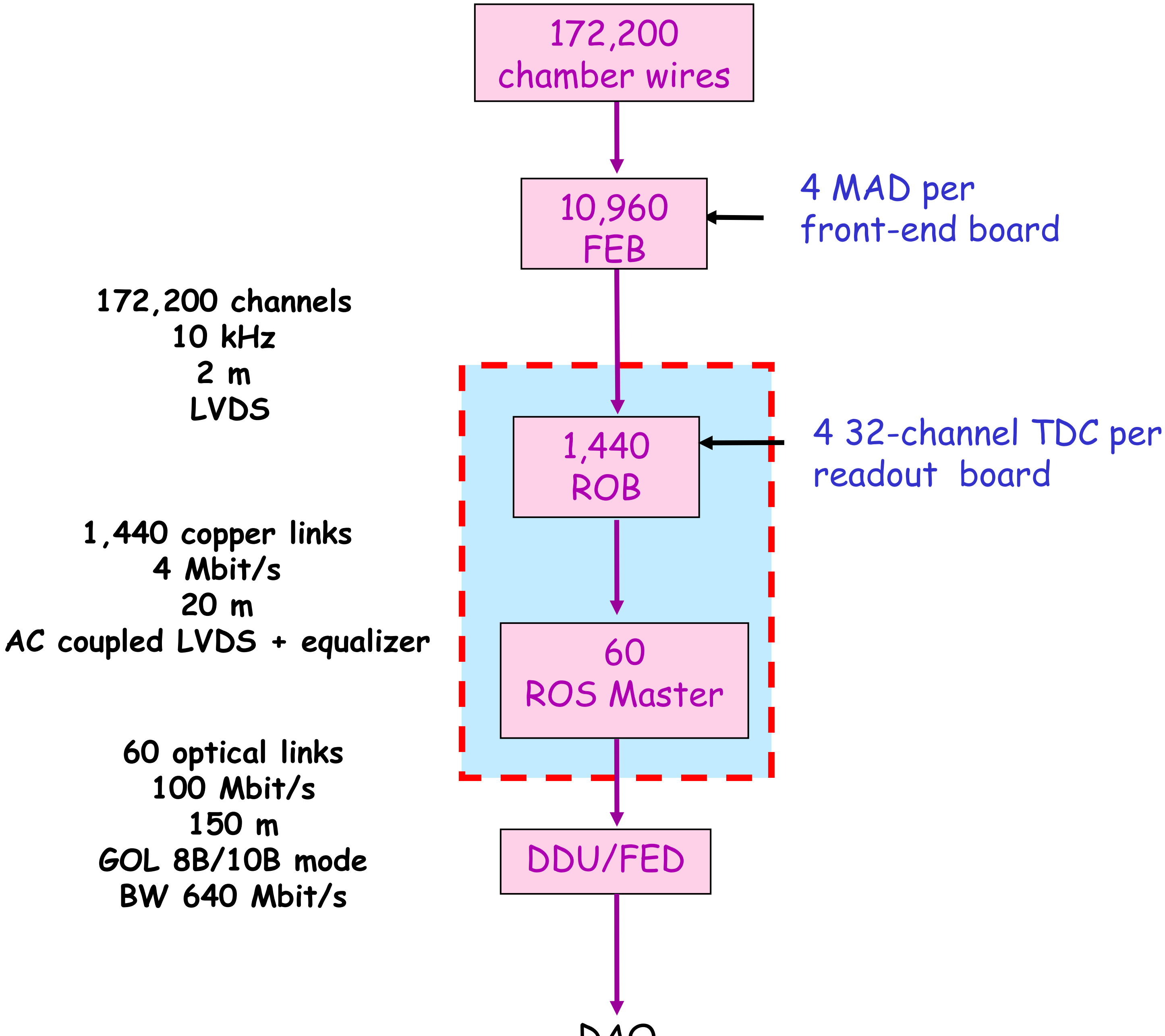


Expect to finish production in June 2005

Barrel Muon Installation



DT Readout system overview



Main Results achieved in the last three years

Activity coordinated by Carlos Willmott

- Definition and specification of the TDC developed by CERN Microelectronics Group for CMS barrel muon chambers

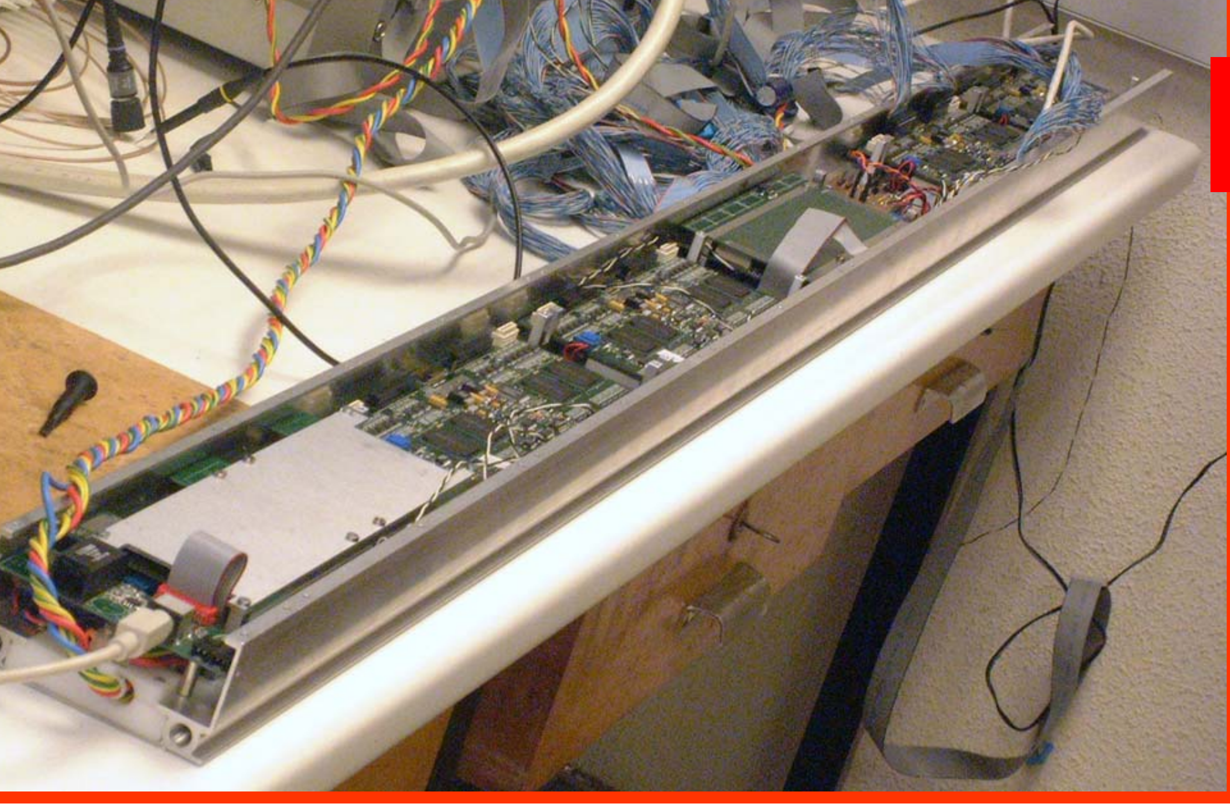
- Characterisation and qualification of HPTDC to be operated under CMS requirements and environmental conditions.

- Development of the final version of Readout Board (ROB) for first level processing and digitisation of chamber signals.

- Production of a pre-series of 30 ROB to validate and check the correctness of the design.

- Development of the first prototype of a Readout Server Board (ROS) to collect data from one sector of chambers and data transmission to Front-End Driver (FED) at DAQ.

- Design and construction of first Minicrate prototype.



MINICRATE

Assembly of all Minicrate with ReadOut Boards is CIEMAT responsability

Full production of ROB is proceeding now in a Spanish firm

READOUT BOARD (ROB)

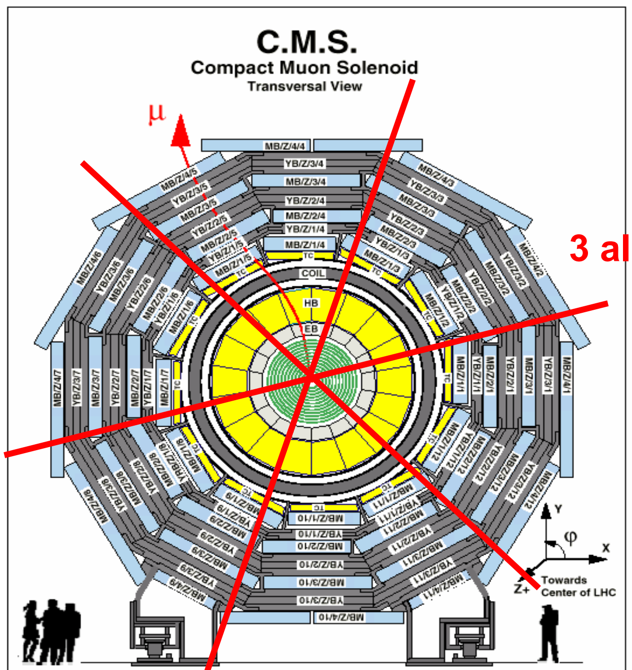
The CMS Alignment System

Task of the align. system

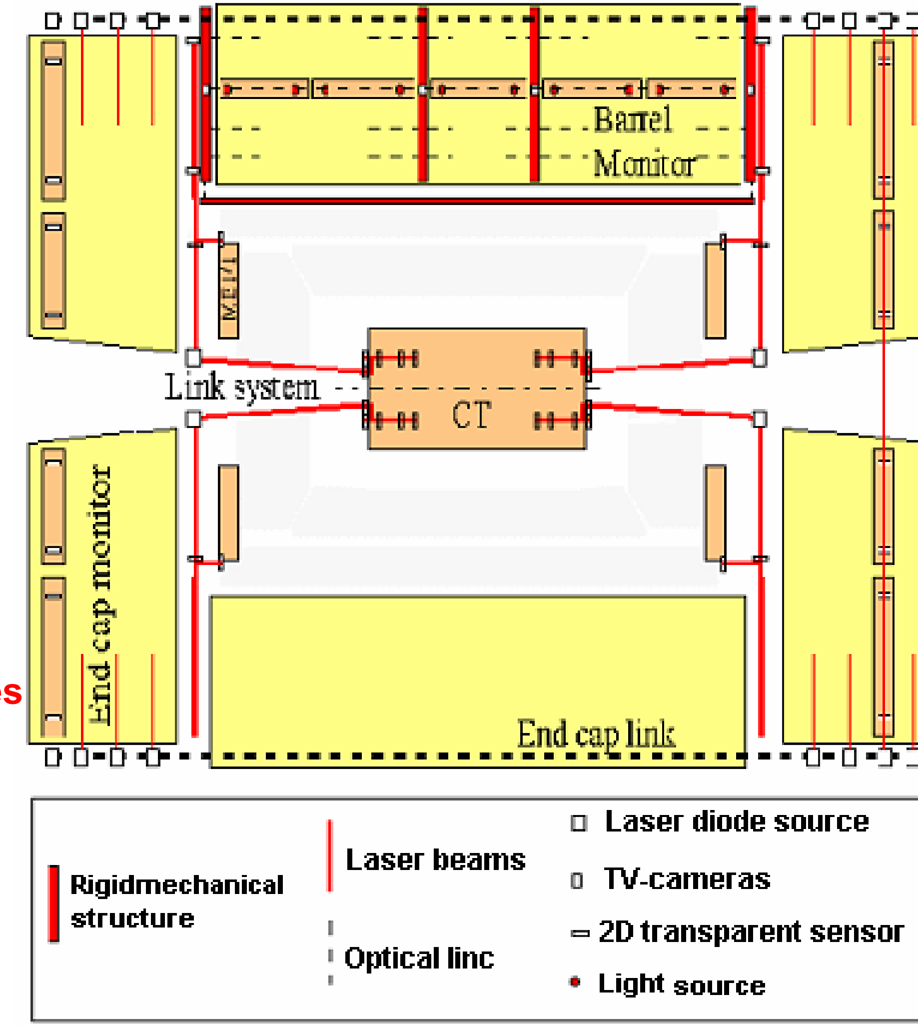
- Measure the relative position of the μ-chambers, and wrt to the TK detectors
- Monitor the stability of Tracker & Muon detectors

Building blocks: 4 subsystems

- Internal tracker align.
- Internal muon : barrel and endcap
- The link tracker ⇔ muons (3 alignment planes)



3 alignment planes



The "link" alignment system

In collaboration with the High Energy Physics Group in Santander University

Activity coordinated at CIEMAT by Antonio Ferrando

- Tests and calibration of system components
  - Semitransparent sensors (ALMYS) and alternative sensors (CMOS)
  - Tiltmeters and laser levels
  - Periscopes (in collaboration with CIDA)
  - Irradiation tests (NAYADE γ source at CIEMAT)
- Electronics associated to these components

CMS - Software

Activity coordinated by Nicanor Colino

First software activities related to muon detector design studies, test beam analysis and chamber production.

Setup of a small farm to contribute to the official CMS Monte Carlo Production

Participation in the EU DataGrid project (Test bed)

Creation of the Portal de Información Científica, PIC (DURSI, IFAE)

Starting a three year coordinated project (LCG-ES) in collaboration with other Spanish experimental groups and PIC.

Responsibilities in the CMS Simulation package OSCAR

Main future Milestone:

Contribute to the studies and preparation of the CMS Computing and Physics TDR´s

CIEMAT detector construction activities in CMS are progressing well, after a difficult start.
Still some concerns about installation phases.

Resources are drifting from L3 towards CMS software activities. We are determined to build a strong analysis team.

A total a 3 PHD Thesis have been presented up to now (another 3 are in progress).

In average 4 presentations of CMS at International Conferences and Workshops have been made every year by CIEMAT people.

Universidad Autónoma de Madrid at the CMS experiment

Manpower

- ✓ 2 Senior Physicists full time at CMS
- ✓ 2 Grad-students

Project Goals (started 1.5 years ago)

- ✓ Muon Trigger: DT Track Finder (DTTF)
- ✓ Muon Trigger: DTTF Online Control Software
- ✓ Hadron Calorimeter in Muon Trigger
- ✓ Test of Muon Detector Chambers at CERN
- ✓ Particle Physics Phenomenology

The nTOF Experiment

Participation in the nTOF experiment at CERN

Main interest of the CIEMAT group is the measurement of the neutron reaction cross sections of actinide isotopes.

CIEMAT is responsible of the workpackage for capture cross sections within the FP5 European project nTOF-ADS

The CIEMAT group is also involved on the Monte Carlo simulation of the experiment, the definition of the neutron beam optics, data analysis, and the setup of the total absorption calorimeter.

This activity is integrated in a larger R&D program on P&T (Partitioning and Transmutation). The use of Accelerator Driven nuclear Subcritical systems, requiring high power proton accelerators (E close to 1 GeV), is being evaluated as a possible technology for nuclear waste management.

Program of nTOF measurements (2002-2004) from the EC-contract

Fission cross sections of Th-cycle and transuranic isotopes: The main isotopes considered are ^{237}Np, ^{239}Pu, ^{241}Am, ^{243}Am, ^{245}Cm, ^{232}Th, ^{233}U, ^{234}U and ^{236}U (plus ^{235}U and ^{238}U and ^{209}Bi- reference standard isotopes). The main objective will be to cover the energy range from 1eV to 20 MeV, but the higher energy limit will be extended as much as allowed by statistics.

Capture cross sections of transuranic isotopes: Although several other isotopes were interesting targets, limitations in the sample availability and intrinsic radioactivity, have reduced the present list of considered samples to: ^{237}Np, ^{240}Pu, ^{241}Pu, ^{241}Am, ^{243}Am and ^{245}Cm. The aimed energy range of measurements will be from 1eV to aprox. 1 MeV.

Capture cross sections of Th-cycle isotopes: Including measurements of ^{232}Th, ^{231}Pa, ^{233}U, ^{234}U and ^{236}U in the range from 1eV to ~1 MeV.

Capture cross sections of non fissionable isotopes: Both long lived fission products and possible coolant isotopes are proposed: ^{151}Sm, ^{129}I, ^{99}Tc, ^{79}Se, ^{204,206,207,208}Pb and ^{209}Bi, always intending to cover the neutron energy range from 1eV to ~1 MeV.

Total cross sections: Performed by transmission, most probably in the IRMM facilities. The isotopes are ^{237}Np, ^{129}I, ^{239}Pu and ^{240}Pu.

(n,xn) cross sections: Performed in two ways, by TOF at CERN and by activation methods in several facilities at Europe providing monoenergetic neutrons. Adding together both types of installations, measurements are proposed for ^{237}Np, ^{232}Th, ^{231}Pa, ^{239}Pu, ^{241}Pu, ^{241}Am, ^{243}Am, ^{233}U, and ^{207}Pb.

Test and Calibration Measurements: Au, Ag and Mg samples.

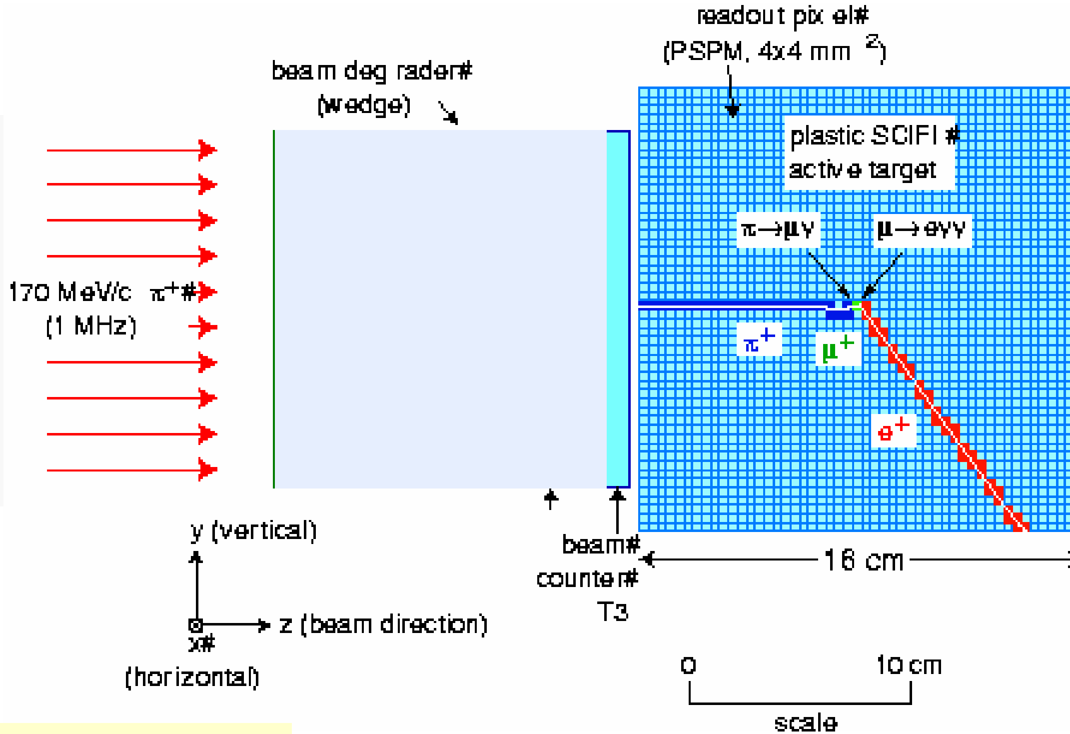
The FAST Experiment

FAST Experiment

The goal of the experiment is the measurement of the Fermi constant to 1 ppm
(10 times better accuracy than the present world average)

BEAM:

pion beam at PSI
p = 170 MeV/c (3%)
size = 10x16 cm^2
rate = 1 Mhz
purity = 90%

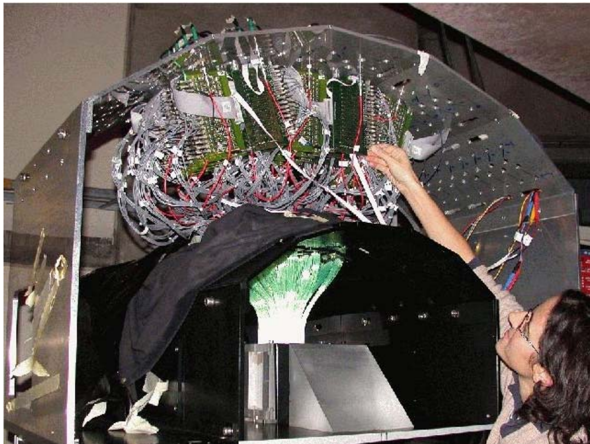


TARGET:

40x40 scintillator “baguettes” of 4x4x1600 mm^2
(25 p.e./pixel for a mip)

READOUT

100 PMT’s with photocathode of 4x4 pixel



FAST Experiment

FAST Collaboration: 18 physicist from 5 institutes:
CERN, PSI, CIEMAT, University of Geneva, University of Nimegen

FAST Schedule

Experiment approved at PSI	2000
Prototype test, re-design of DAQ	2001
System integration test at PSI	2002
Detector Installation and check out	2003
Data taking	2003-2004

CIEMAT contribution

CICYT request (2003-2005)
J. Casaus

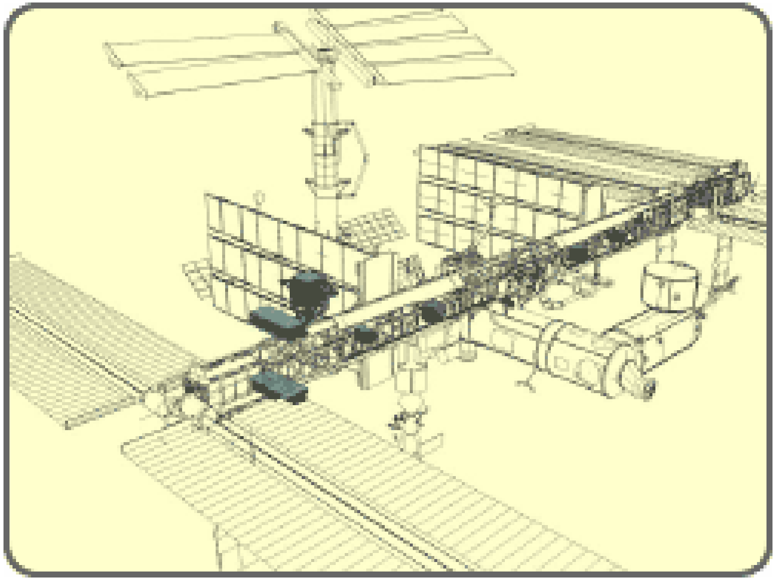
- detector components: PMT's
- level 2 trigger electronics: design and production
- data analysis

The AMS Experiment

The AMS Experiment (CERN Recognized Experiment)

The purpose of the AMS Experiment is to install a particle physics detector on the ISS to perform accurate and high precision primary cosmic ray measurements in the space.

↘ The detector will have capabilities to identify the cosmic ray nuclei with $Z \leq 20$ and to measure their energy spectrum up to the TeV region.



AMS on the ISS

• Orbit altitude	400 km
• Power	2 kW
• Weight	~ 7 T
• Exposure time	> 3 years

Physics Goals

→ Search for Antimatter

Baryon Number non conservation
CP Violation

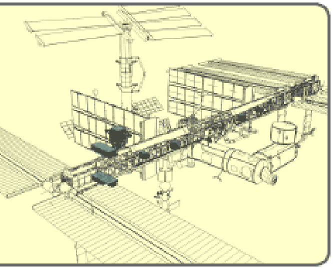
→ Search for Dark Matter:

Candidates coming from Particle Physics Extensions of the Standard Model: SUSY

→ Astrophysics studies

Exhaustive study of the cosmic ray composition and relative abundance of the light nuclei isotopes

The AMS Experimental Program



The AMS Experiment is part of the scientific program of the International Space Station and it is the only approved and scheduled Particle Physics experiment on the ISS.

Approved (NASA - DOE MOU)	1995 (rev. 1999)

- AMS Collaboration is responsible for the construction and performance of the detector
- NASA provides two shuttle flights

- Phase 1: Engineering flight
  - Test the performance of the detector
  - Study the *background* in "real conditions"

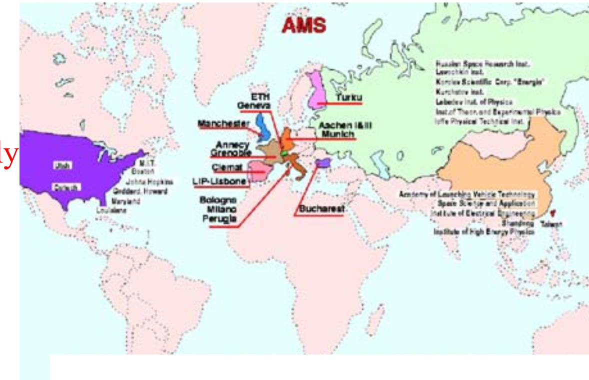
June 1998 STS-91 Mission (10-days)

- Phase 2: Transportation and installation on the ISS
  - 3 years of data taking to perform the physics program

Scheduled for October 2005

a I. Physikalisches Institut, RWTH, D-52056 Aachen, Germany
b III. Physikalisches Institut, RWTH, D-52056 Aachen, Germany
c Laboratoire d'Annecy-le-Vieux de Physique des Particules, LAPP, F-74941 Annecy-le-Vieux CEDEX, France
e Louisiana State University, Baton Rouge, LA 70803, USA
d Johns Hopkins University, Baltimore, MD 21218, USA
f Center of Space Science and Application, Chinese Academy of Sciences, 100080 Beijing, China
g Chinese Academy of Launching Vehicle Technology, CALT, 100076 Beijing, China
h Institute of Electrical Engineering, IEE, Chinese Academy of Sciences, 100080 Beijing, China
i Institute of High Energy Physics, IHEP, Chinese Academy of Sciences, 100039 Beijing, China
j University of Bologna and INFN-Sezione di Bologna, I-40126 Bologna, Italy
k Institute of Microtechnology, Politechnica University of Bucharest and University of Bucharest, R-76900 Bucharest, Romania
l Massachusetts Institute of Technology, Cambridge, MA 02139, USA
m National Central University, Chung-Li, Taiwan 32054
n Laboratorio de Instrumentacao e Fisica Experimental de Particulas, LIP, P-3000 Coimbra, Portugal
o University of Maryland, College Park, MD 20742, USA
p INFN Sezione di Firenze, I-50125 Florence, Italy
q Max–Plank Institut fur Extraterrestrische Physik, D-85740 Garching, Germany
r University of Geneva, CH-1211 Geneva 4, Switzerland
s Institut des Sciences Nucleaires, F-38026 Grenoble, France
t Helsinki University of Technology, FIN-02540 Kylmala, Finland
u Instituto Superior Tecnico, IST, P-1096 Lisboa, Portugal
v Laboratorio de Instrumentacao e Fisica Experimental de Particulas, LIP, P-1000 Lisboa, Portugal
w Chung–Shan Institute of Science and Technology, Lung-Tan, Tao Yuan 325, Taiwan 11529
x Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas, CIEMAT, E-28040 Madrid, Spain
y INFN-Sezione di Milano, I-20133 Milan, Italy
y INFN-Sezione di Pisa, I-50100 Pisa, Italy
z Kurchatov Institute, Moscow, 123182 Russia
aa Institute of Theoretical and Experimental Physics, ITEP, Moscow, 117259 Russia
ab INFN-Sezione di Perugia and Universita´ degli Studi di Perugia, I-06100 Perugia, Italy
ac Academia Sinica, Taipei, Taiwan
ad Kyungpook National University, 702-701 Taegu, Korea
ae University of Turku, FIN-20014 Turku, Finland
αf Eidgenossische Technische Hochschule, ETH Zurich, CH-8093 Zurich, Switzerland

Europe
US
Asia

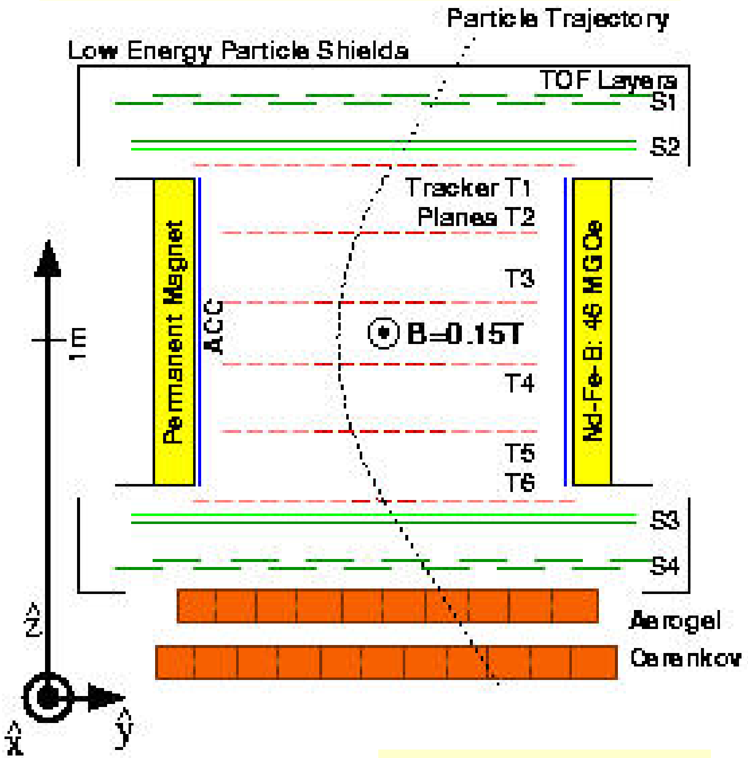


The AMS Experiment: AMS01

- Phase 1: Engineering flight

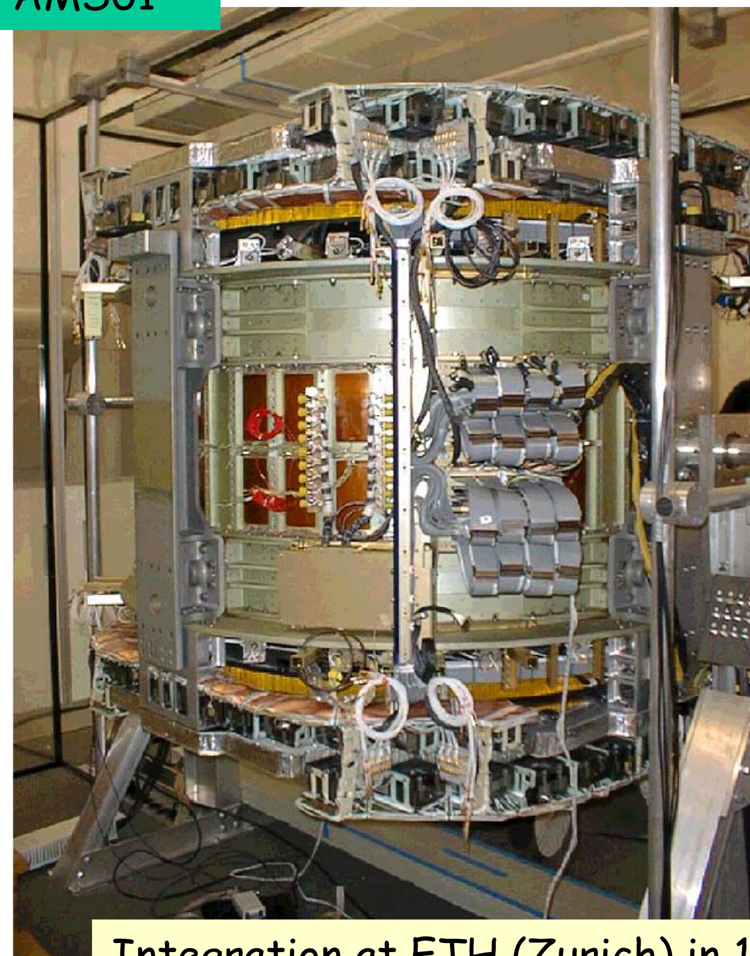
June 1998 STS-91 Mission
(10-days)

Geometrical Acceptance = 0.30 m^2 sr



Weight	3 T
Power	1 kW

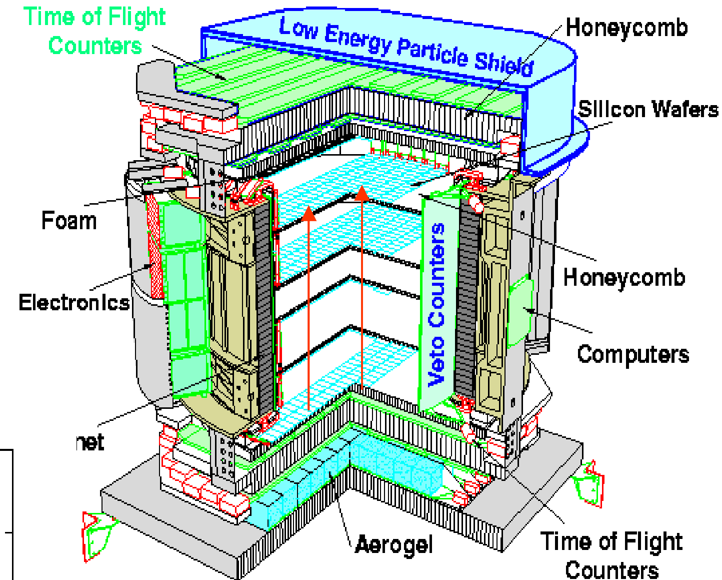
AMS01



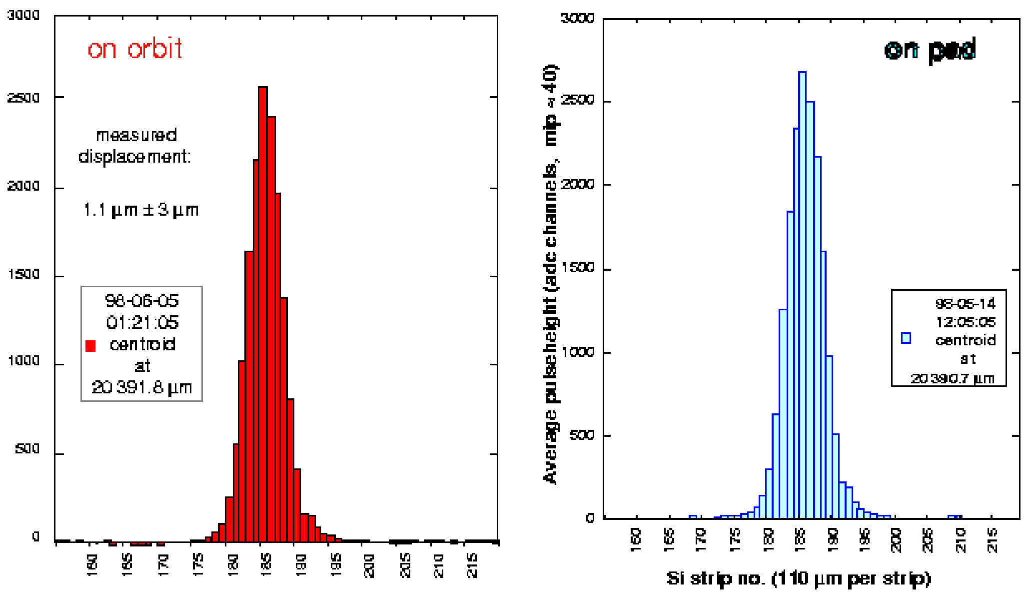
Integration at ETH (Zurich) in 1997

AMS01 (STS-91): Detector performance

June 1998: STS-91 Mission (10 days)



AMS Si-Tracker IR-Laser alignment control

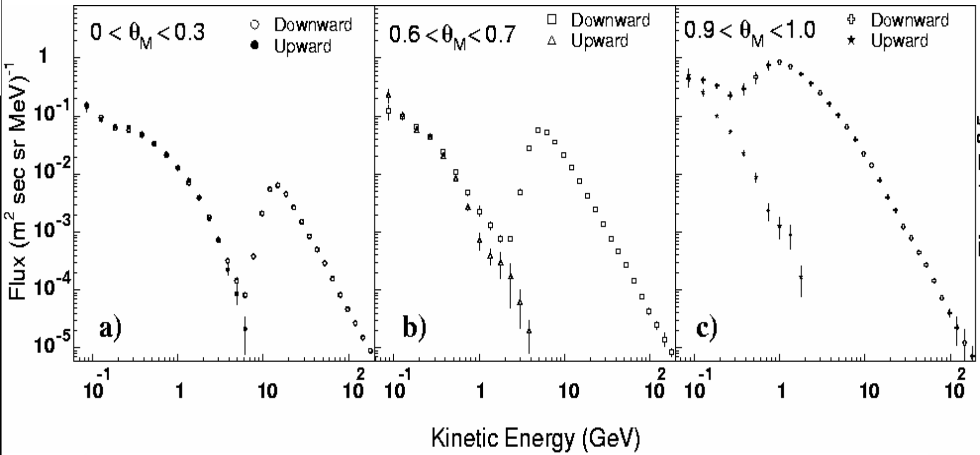


Tracker Alignment System

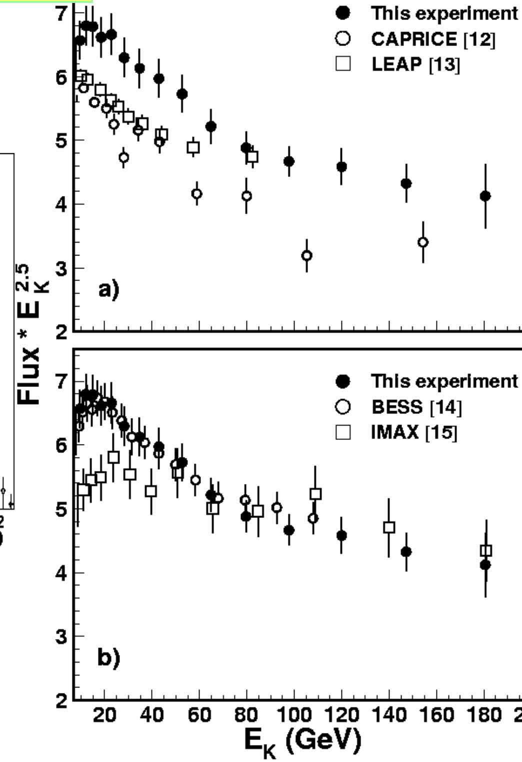
AMS01: Physics Results

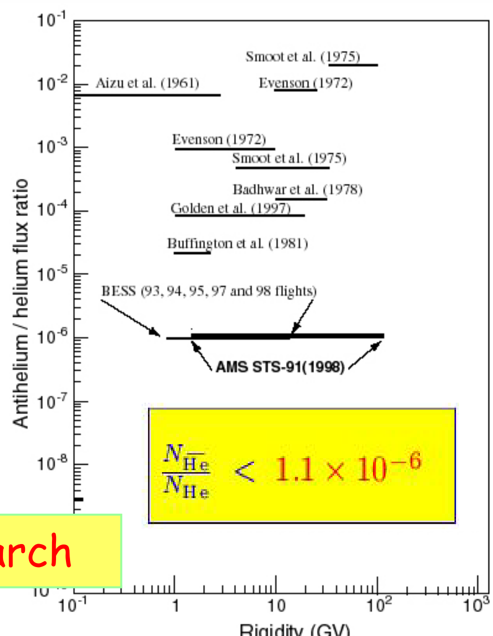
Trigger rate 100 - 700 Hz

~ 10^8 events



Proton Flux

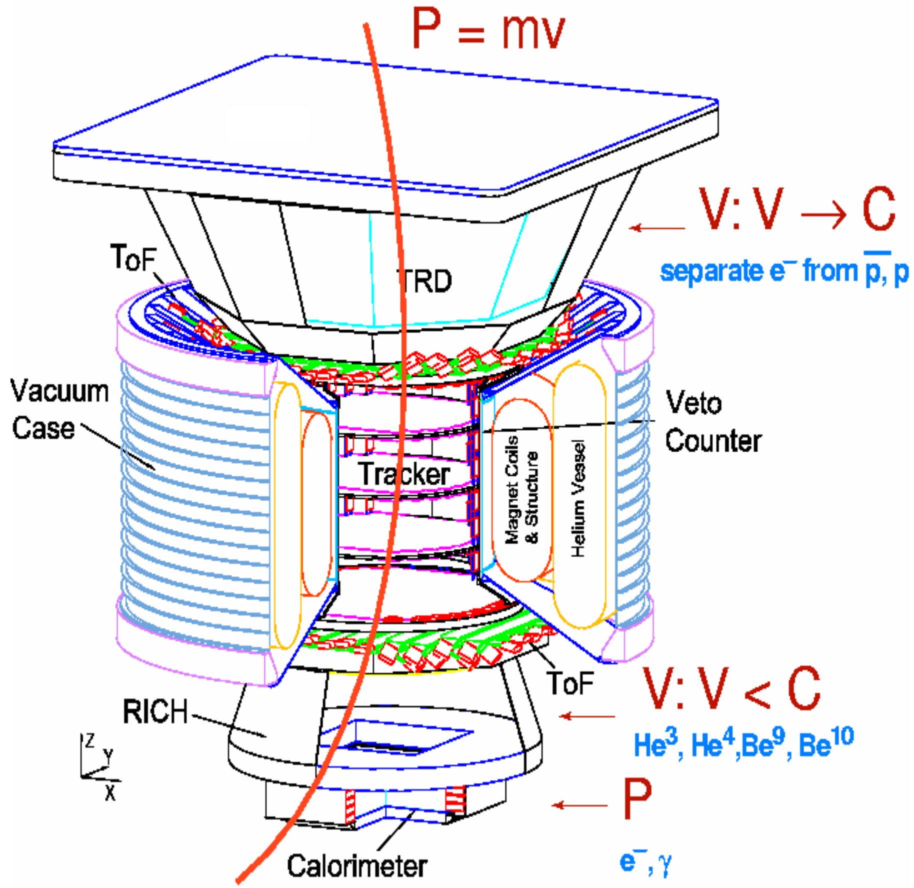




Antimatter Search

- Cosmic Protons, Leptons and Helium
  - Phys. Lett. B 472 (2000)
  - Phys. Lett. B 484 (2000)
  - Phys. Lett. B 490 (2000)
  - Phys. Lett. B 494 (2000)
  - Phys. Rep. 366/6 (2002)
- Search for Antihelium in Cosmic Rays
  - Phys. Lett. B 461 (1999)

AMS02 Detector



- Phase 2: Transport and installation on the ISS

Scheduled for October 2005
(UF4.1)

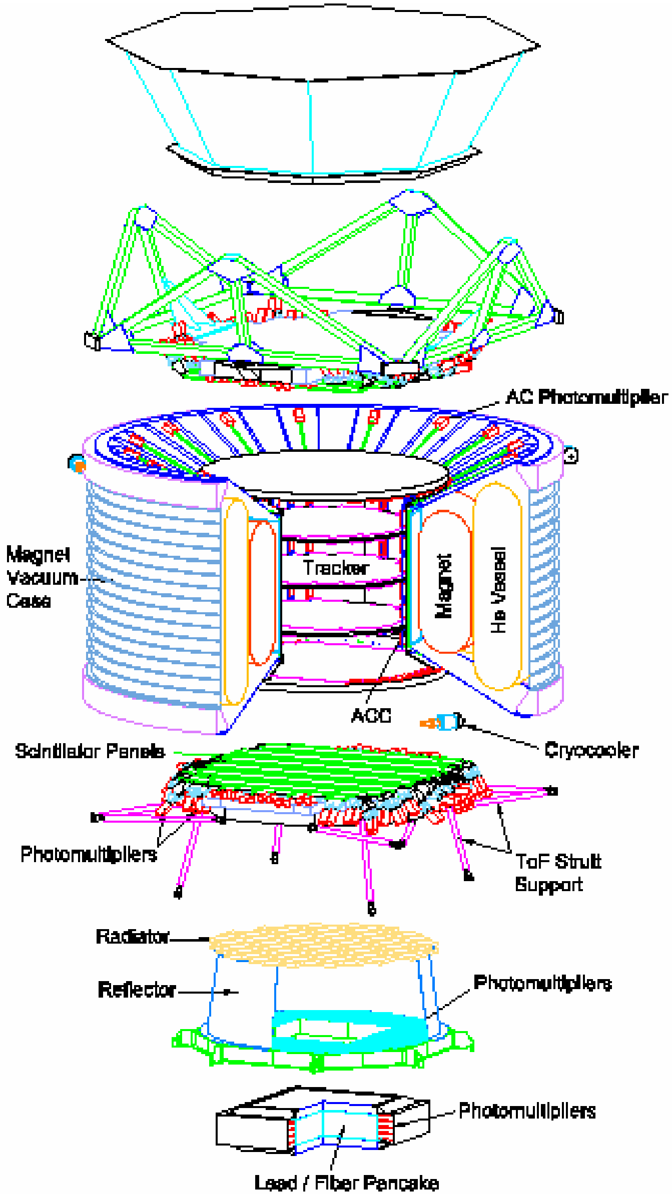
Sub-Detector		AMS-01	AMS-02
Magnet	BL^2	0.15 Tm^2	0.78 Tm^2
Tracker	Planes	6	8
	$\sigma(p) / p$	10 %	1.5 %

New Sub-Detector			
TRD & EMC	e/p γ	-	$< 10^{-6}$
RICH	$\sigma(\beta) / \beta$	3 %	0.1 %

Geometrical Acceptance = 0.45 m^2 sr

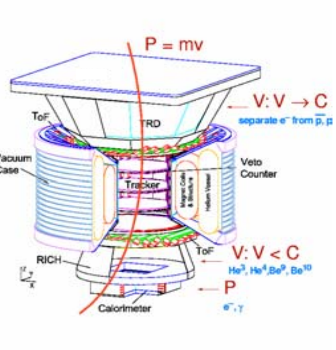
Weight 6 T
Power 2 kW

AMS02 Detector



TRD: Transition Radiation Detector	GERMANY
ToF: (s1,s2) Time of Flight Detector	ITALY
TR: Silicon Tracker	GERMANY, HOLLAND, ITALY SWITZERLAND
ACC: Anticoincidence Counter (veto Counter)	GERMANY
MG: Magnet **CC:** Cryocooler	U.K, USA, SPAIN, SWITZERLAND
ToF: (s3,s4) Time of Flight Detector	ITALY
RICH: Ring Image Cherenkov Counter	FRANCE, ITALY, PORTUGAL SPAIN
EMC: Electromagnetic Calorimeter	CHINA,FRANCE, ITALY

AMS02: Expected performanes



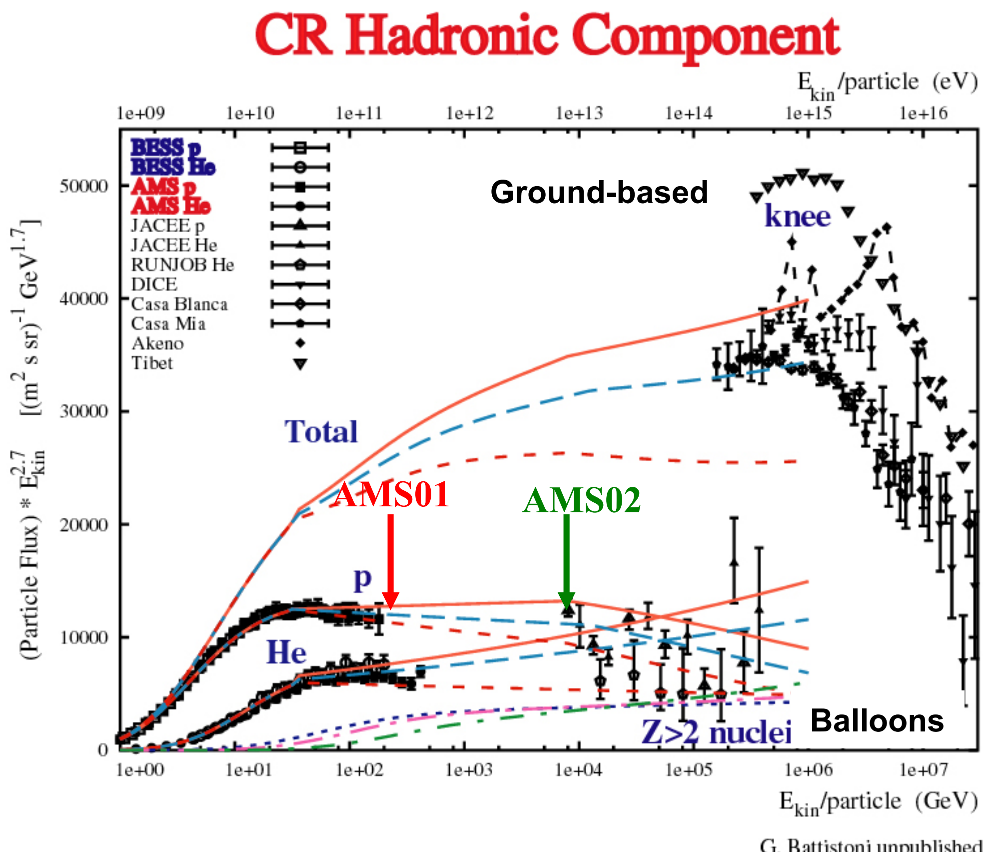
In 3 years of data taking AMS will measure the cosmic ray fluxes up to energies ~ 1 TeV

~ 10^8 proton events with E > 100 GeV

~ 10^7 He events with E > 100 GeV/n

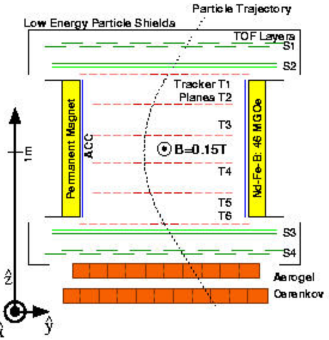
~ 10^5 C events with E > 100 GeV/n

article type	Energy range
	~ 1 TeV
e,….C	~ 1 TeV
ght sotopes	10 GeV/n
	200 GeV
	200 GeV
nti – e,…C	~ 1 TeV
	~ 1 TeV
	300 GeV



CIEMAT participation in AMS01-AMS02

CIEMAT Participation in AMS01 (1997-2000)



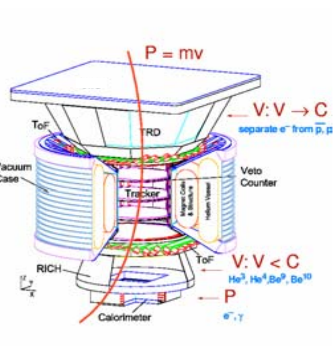
Activities:

Software development and Analysis

- Integration at ETH (Zurich)
- Integration and validation at KSC (NASA)
- Data taking at JSC (NASA)
- Calibration (GSI & CERN)
- Data Analysis (CERN & CIEMAT)

External Funding: CICYT 0.6 MEuros

CIEMAT Participation in AMS02 (2000- 2005)

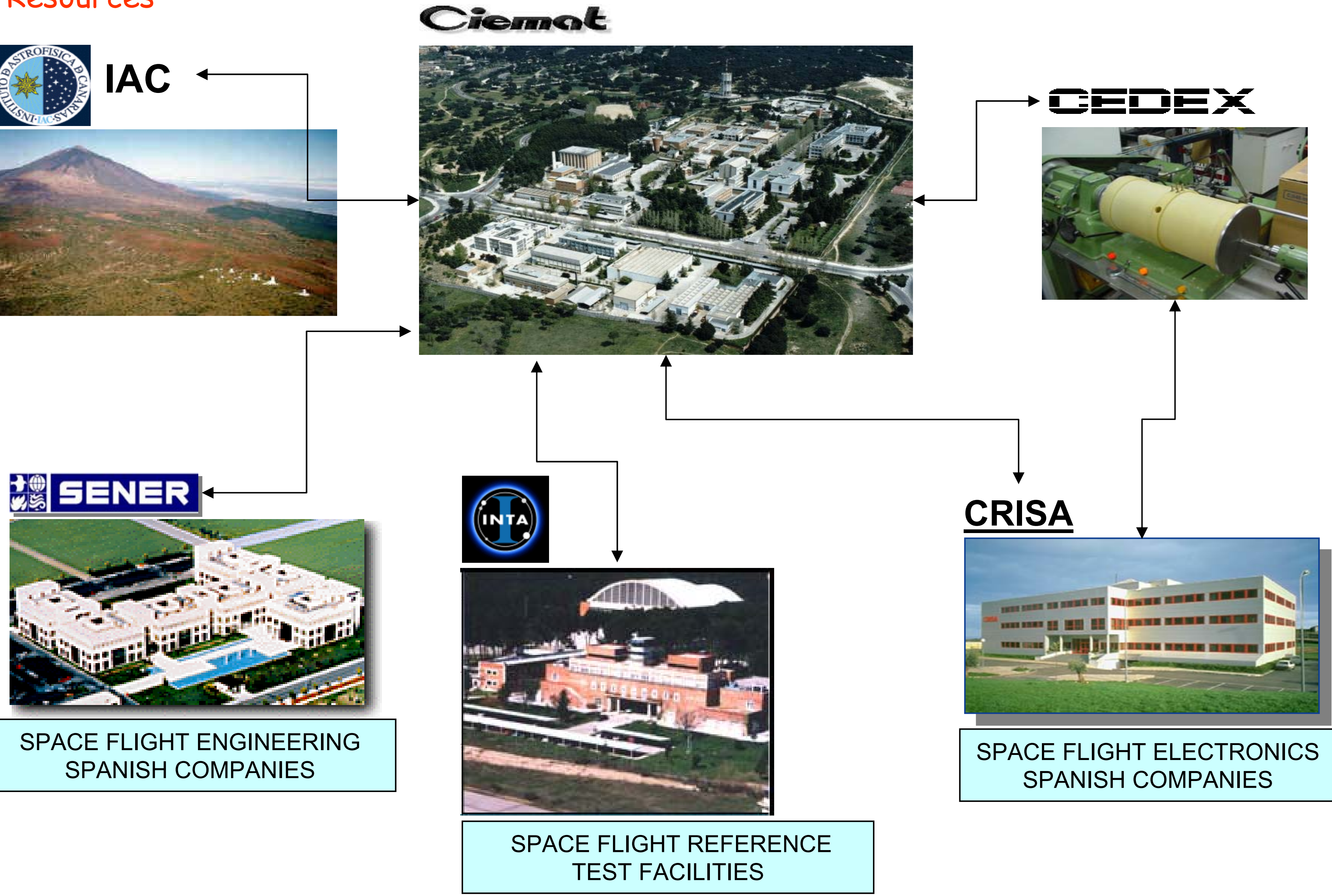


Activities

- Software development and Analysis
- Participation in the AMS02 Construction
  - Superconducting Magnet Electronics
  - Cerenkov Counter Detector (RICH)

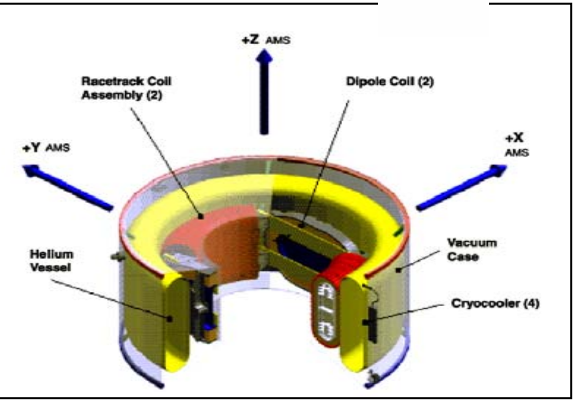
External Funding: CICYT+CDTI 6 MEuros

Resources

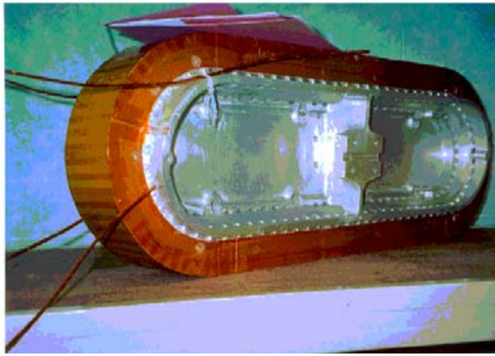

Ciemat
IAC
CEDEX
SENER
INTA
CRISA
SPACE FLIGHT ENGINEERING SPANISH COMPANIES
SPACE FLIGHT REFERENCE TEST FACILITIES
SPACE FLIGHT ELECTRONICS SPANISH COMPANIES

AMS Magnet

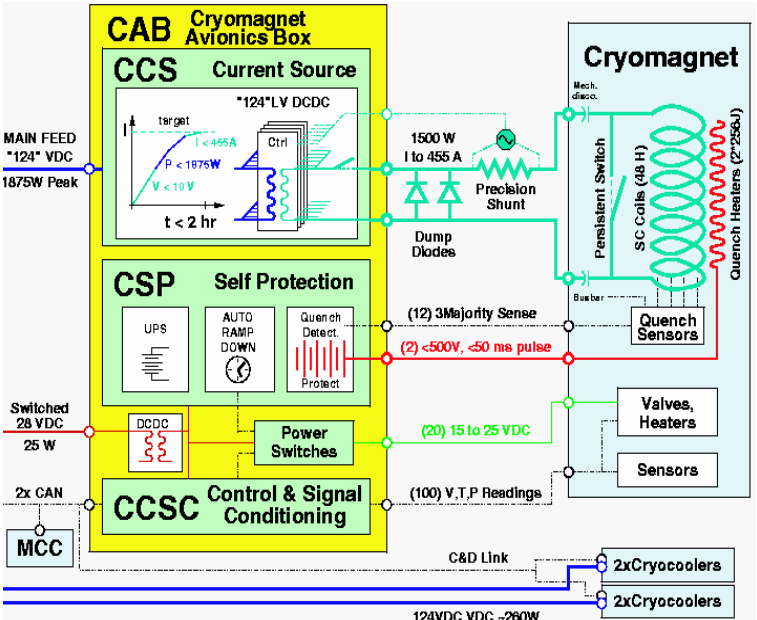
ETH Zürich MIT Ciemat **CRISA**

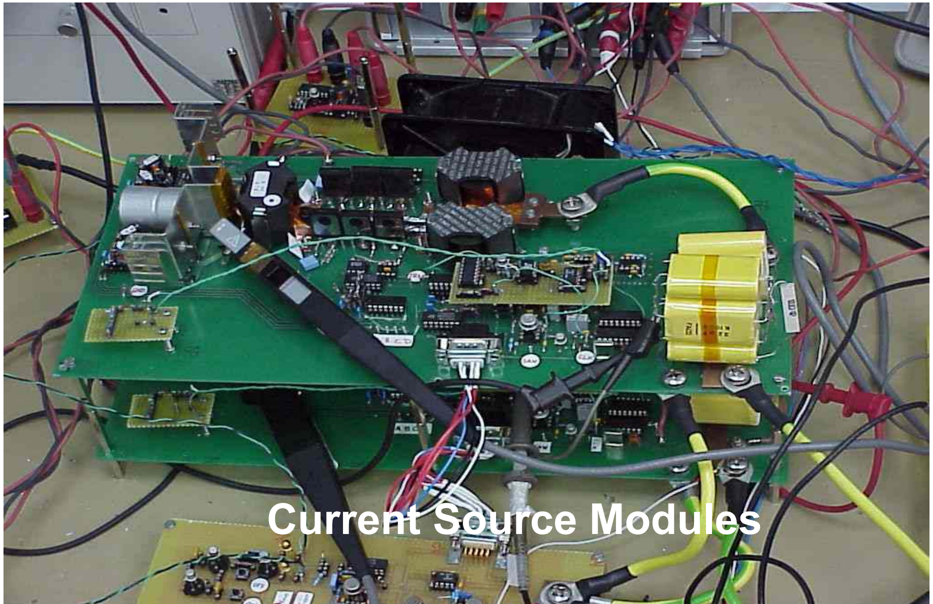


Main Parameters of the AMS-02 Magnet System	
Central magnetic field	0.87 T
Dipole bending power	0.78 Tm^2
Nominal operating current	459 A
Nominal magnet inductance	48.9 H
Stored energy	5.15 MJ
Peak magnetic field on Helmholtz coils	6.6 T
Peak magnetic field on racetrack coils	5.9 T
Maximum stray field at R=3 m	3.9 mT
Magnetic torque	.27 Nm
Superconducting material	NbTi
Work temperature (Superfluid Helium)	1.8K

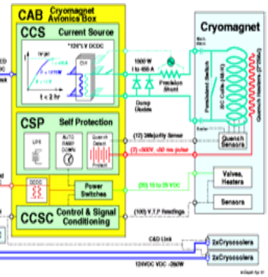


Laboratory Breadboard of Cryomagnet Current Source (CRISA)





Superconducting Magnet: CCS Status



• CCS: CIEMAT - CRISA Contract ~ 1,2 MEuros

❑ CCS Working plan:

Year	Concept
2001	- Signature of the Contract - Requirements Review and Working Plan - Final Design
2002	- Laboratory Prototype - Prototype Testing - Development of the Qualification Procedure
2003	- Qualification Model Unit and Test - Flight Model Unit and Test

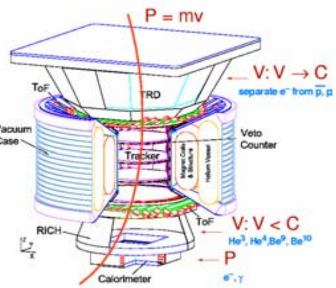
❑ CCS Status:

- o Current Source:
  - Detailed electrical design: 100 %
  - Modularity: 100%
  - Part list: 90%
  - Major functionalities validated in BB
- o Control
  - Voltage loop: Design 100 % (validated in BB)
  - Current loop: Design 100 %
  - Power loop: Design 100 %
- o TM/TC
  - Detailed Block Diagram
  - Preliminary Parts List

Responsible: L. Garc

✓ CSP-CCSC-PS: DOE-ETH - CRISA Contract ~ 2,8 MEuros

RICH Requirements



Cerenkov Radiation Detector

Independent measurement of the velocity (β) of charged particles

$$\sigma(\beta) / \beta \approx 10^{-3} \text{ @ } \beta = 1 \text{ (protons)}$$

- Measurement of charge for ions with $Z < 20$
- e^{+}/p separation up to energies ≈ 10 GeV

→ Measurement of light isotope abundance ($H/H^2/H^3$, He^3/He^4, Be^{10}/Be^9)

AMS RICH Description (1/2)

AMS RICH Collaboration: CIEMAT (Madrid), INFN (Bologna), ISN (Grenoble), LIP (Lisbon), UMD (Maryland), UNAM (Mexico)

- Size: 50 cm height, 160 cm diameter
- Weight < 200 Kg
- Power ~ 80 Watt

Radiator

- 3 cm of Aerogel (n ≈ 1.03)
- 5 mm of NaF (n ≈ 1.33)
- $N_{p.e.} \approx 10$ (for Z=1; β=1)
- $\beta_{thershold} \approx 0.751$

Reflector

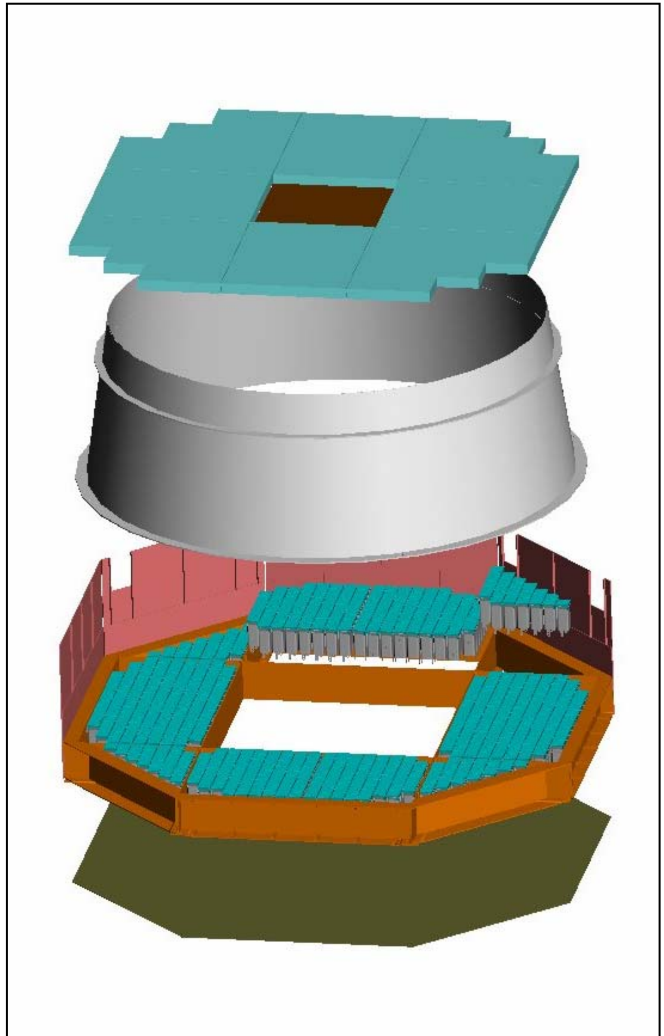
- Reduce photon losses
- Multilayer Structure deposited on a Carbon Fiber Reinforced Composite (CFRC) Substrate

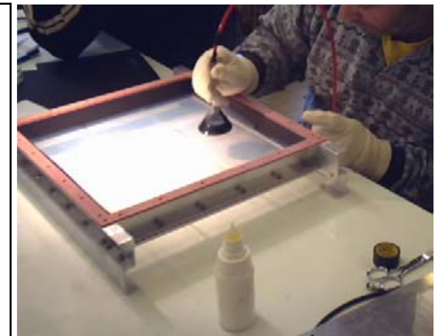
Photon Detection

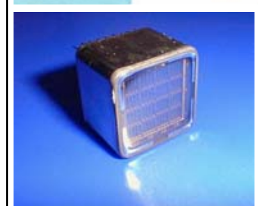
~ 700 photomultipliers (Hamamatsu 7600-00-M16)

- 4×4 mm^2 effective area/pixel
- Gain ~ 10^6 @ 800 V
- Quantum Efficiency ≈ 20 % in the range 250-600 nm

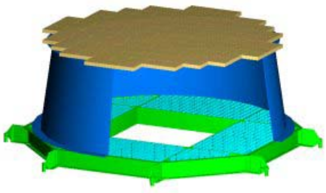
➔ B Field ⊕ 50 % Effective area
→ Shielding
→ Light guides







RICH Commitments



RICH Collaboration:

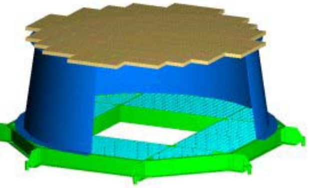
CIEMAT (Madrid), INFN (Bologna), ISN (Grenoble), LIP (Lisbon), UNAM (Mexico)

RICH Commitments:

• Components	PMT's	All	
	Radiator	Ciemat	⊕ (UNAM)
• Mechanics:	Structure	Bologna	⊕ (CGSpace)
	Reflector	Bologna	⊕ (CGSpace)
	Light Guides	Ciemat	⊕ (Sener/IAC)
	Radiator	Ciemat	⊕ (Bologna/CGSpace)
• Electronics:	PMT's F-End	Grenoble	
	Read Out	Ciemat	⊕ (CRISA)
	Power Supplies	Ciemat	⊕ (CAEN/NTE/CSIST)
• Software:	on-line/off-line	Ciemat	⊕ (All)

RICH Assembly — Ciemat ⊕ (All)

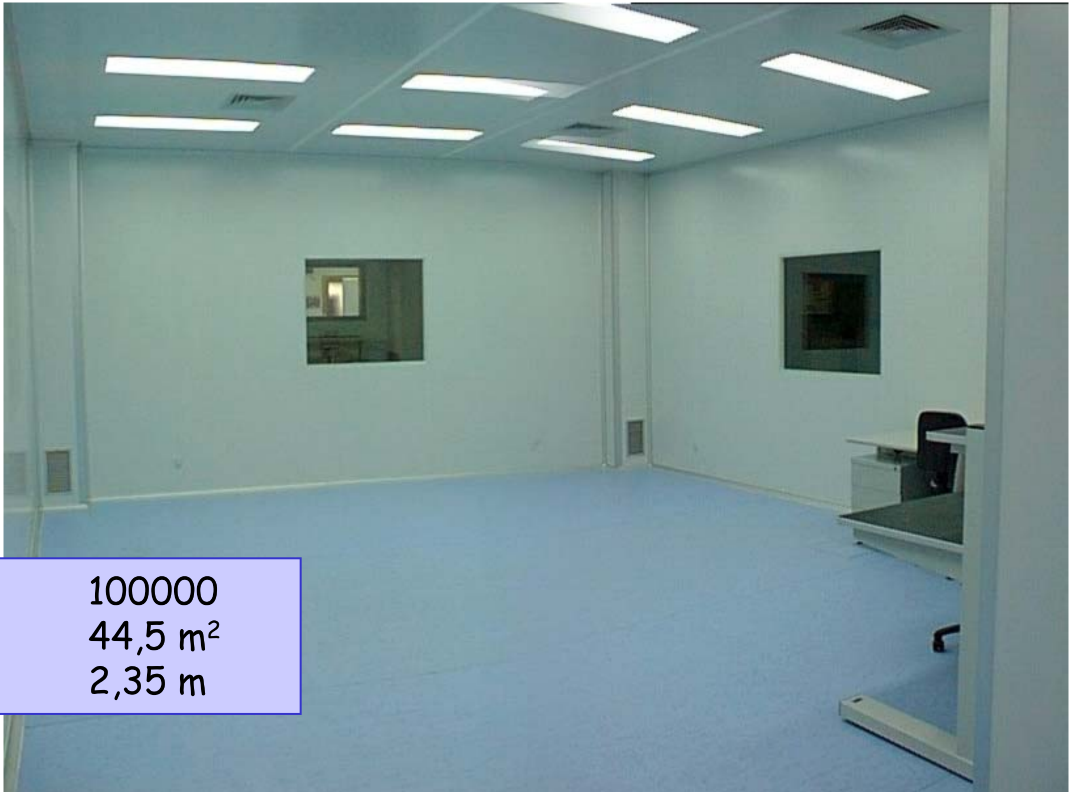
RICH Activities (1/4)



- RICH Assembly — Responsible: C. Díaz, J. Berdugo

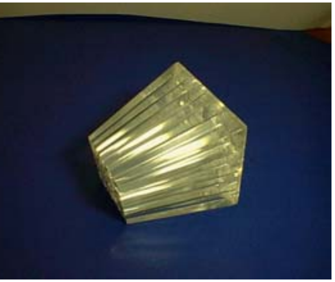
→ Start the RICH Assembly in 2003

Current Status	Shrort term tasks
• Clean Room (class 100000) • Definition of the assembly procedure	• Assembly equipment and special tools • Test station



- Class 100000
- Surface 44,5 m²
- High 2,35 m

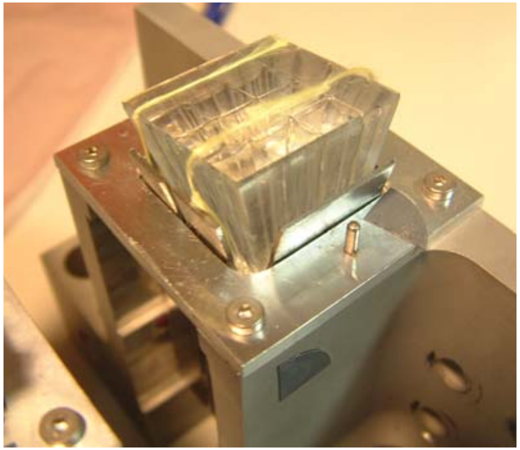
RICH Activities (2/4)



- Mechanics

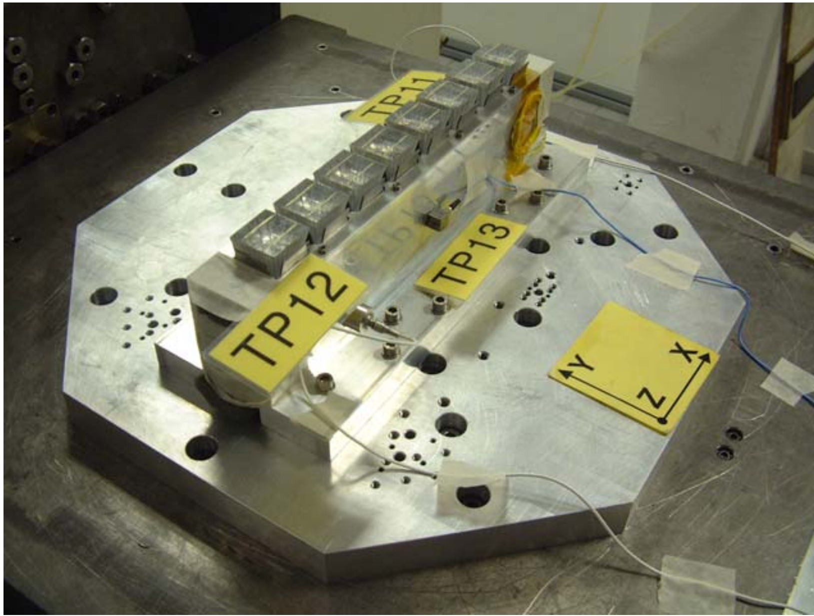
Responsible: C. Díaz, J. Berdug

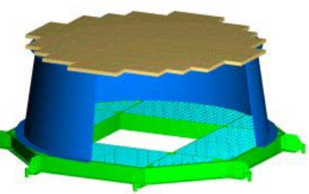
Current status	Short term tasks
• Light Guide design • Optical characterisation of material • LG Fixation system • Production Protocol and quality control • Qualification test	• Flight LG Units Production (700 units)

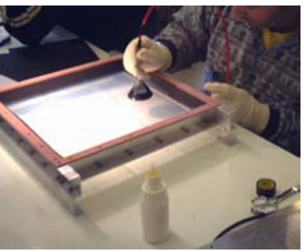


Breakage @ 19.1 g RMS

(6.8 g Max. Req.)





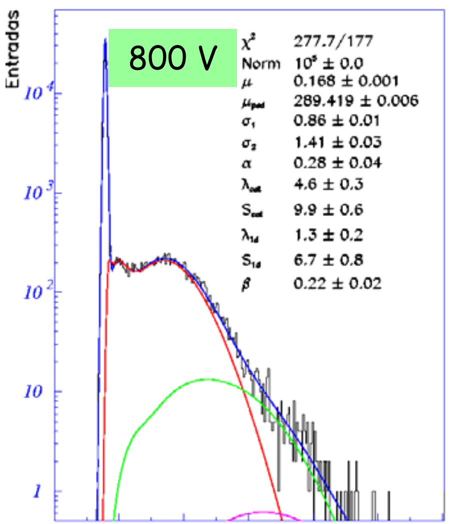


- Components

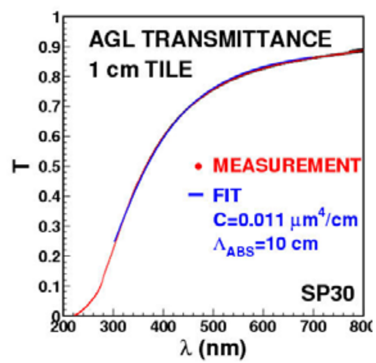
Responsible: C. Mañ

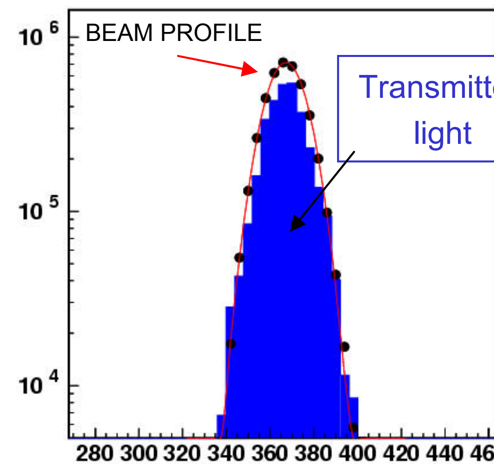
Current Status	Short term tasks
• Acquisition of 225 PMT's • PMT charact. protocol • PMT charact. in magnetic field	• Characterisation and sorting of PMT's
• Aerogel optical characterisation	• Aerogel aging • Final Aerogel Acquisition

Single photon response

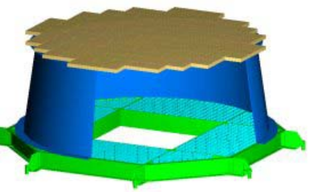


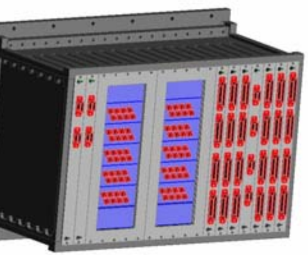
Aerogel light transmittance and dispersion at 500 mm

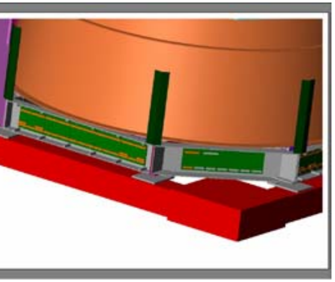




RICH Activities (3/4)





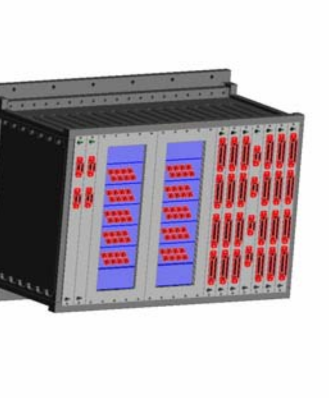


- Electronics

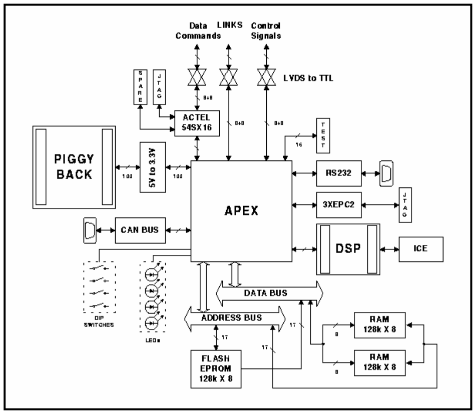
Responsible: J. Mar

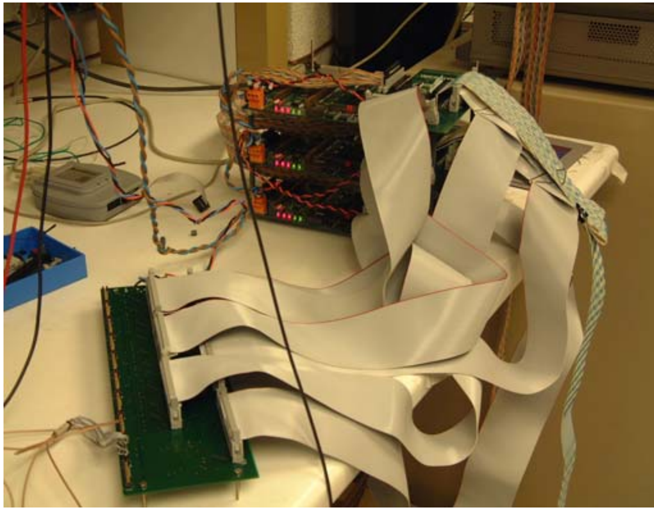
Current status	Short term tasks
• Design - Read Out Board (RDR) - Patch Panels (LV-PP) - Power supplies boards (LV and HV+LR) • Validation of components (test beams) • Engineering Prototypes - RDR (CAEN) - LV-PP (CIEMAT) - Power Supplies (CAEN-NTE) • Data taking and control software implementation • Part List	• Crates - Back Planes - Mechanics (Carlo Gavazzi) - LV Interface boards • QM Boards - RDR (CRISA) - LV-PP (CRISA) - Power Supplies (LV: CSIST, HV+LR: CAEN-NTE) • QM test (INTA) • FM boards and Crates

RICH Electronics: Engineering Prototypes

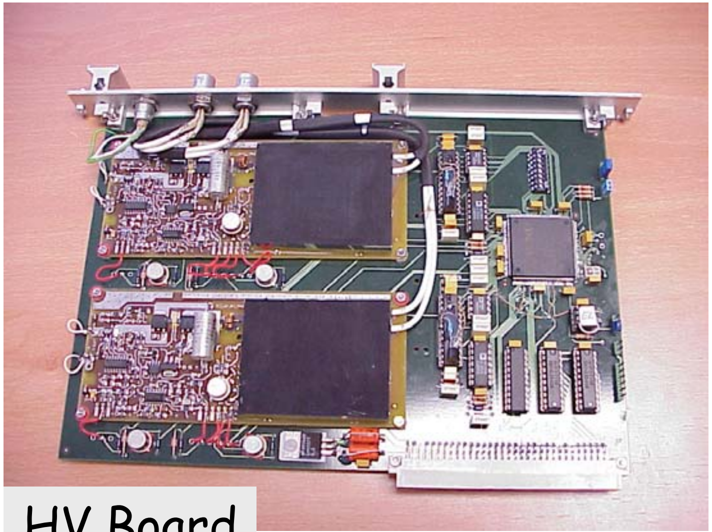


Read-Out Electronics (CIEMAT)

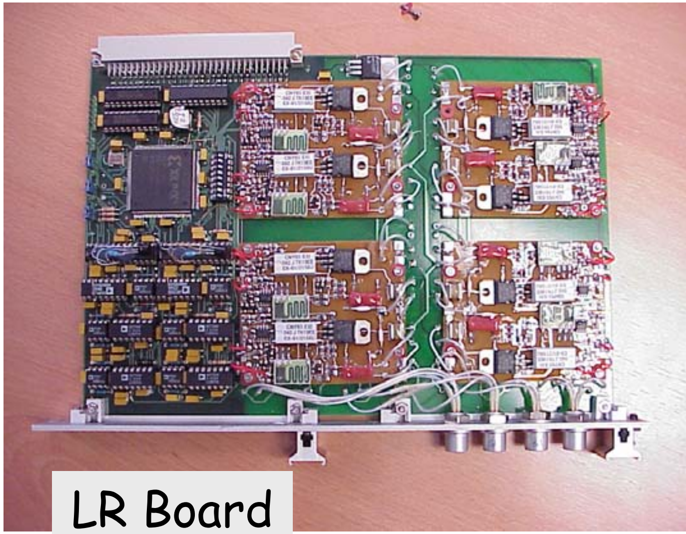




HV Power supply prototype (NTE-CAEN)

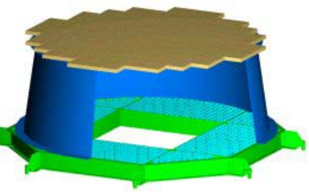


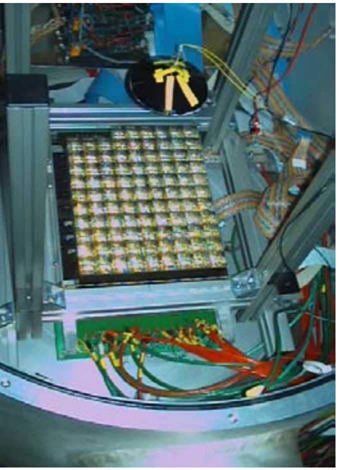
HV Board



LR Board

RICH Activities (4/4)





- R+D (Construction of a prototype ≈ 1/10 RICH)

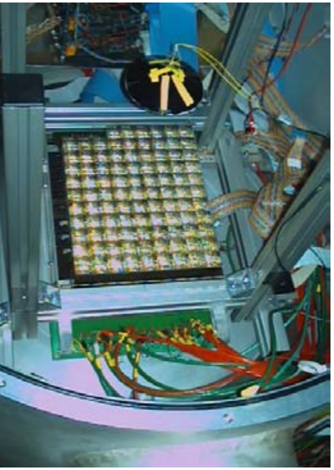
  CIEMAT Contribution

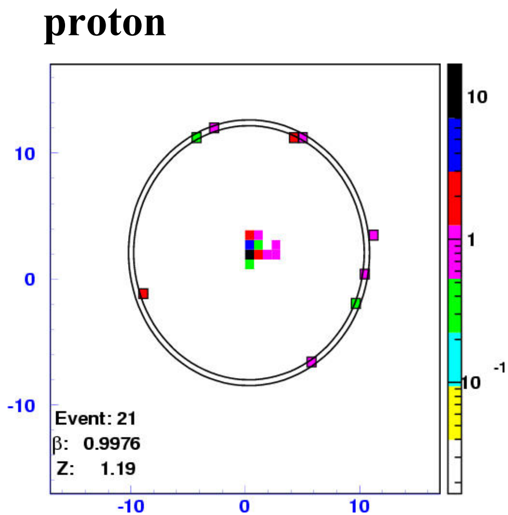
  - Design and construction of the mechanical structure
  - Aerogel acquisition (1.03 y 1.05)
  - Aerogel mechanical structure
  - Characterisation of 60 PMT's
  - Construction of 100 Light guides
  - Data taking system
    - PP
    - RDR
    - Software online

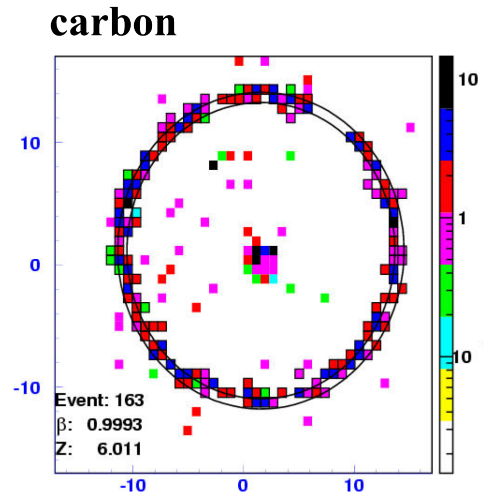
  - Participation in the prototype assembly (at CERN and Grenoble)
  - Participation in the data taking (calibration and cosmic rays)
  - Data analysis and presentation of the results

- Cosmic ray runs
- Test beam at a high energy ion beam (Pb at 20 GeV/n) at CERN (Oct. 2002)

RICH Test Beam

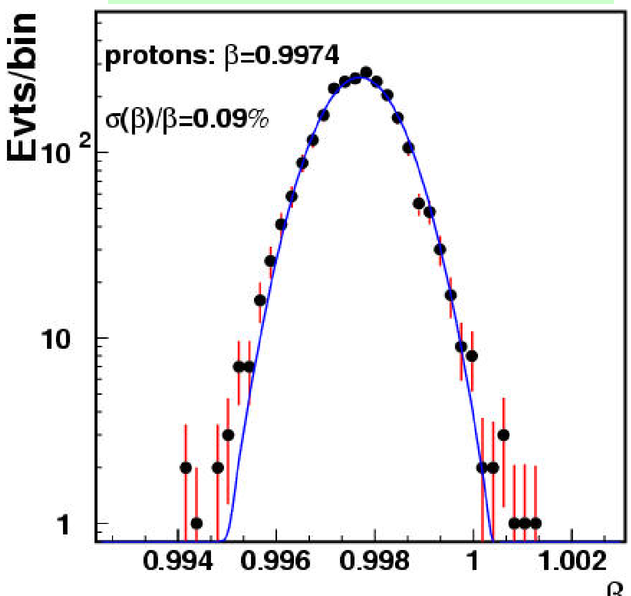


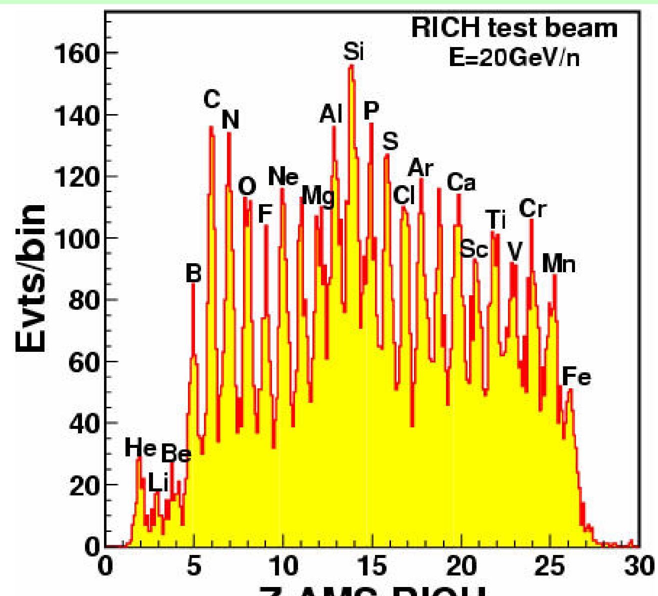




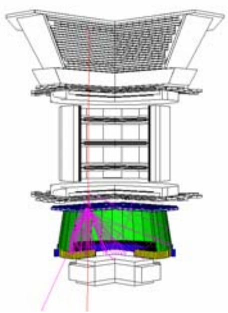
Test Beam protons: $\sigma(\beta)/\beta < 1\times10^{-3}$

Charge measurement up to iron (Z=26) with charge confusion <5 %





Software and analysis (1/2)

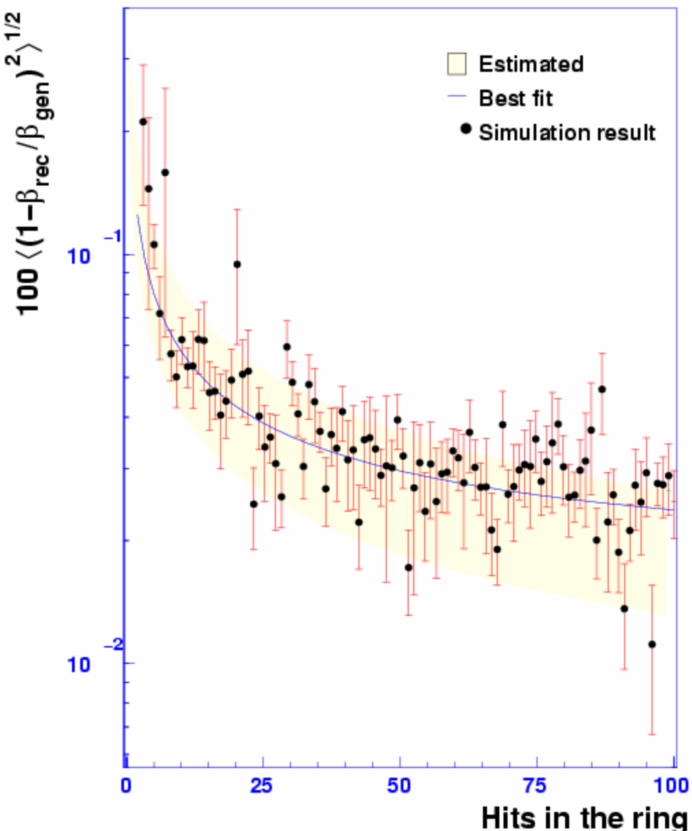


- Software and analysis

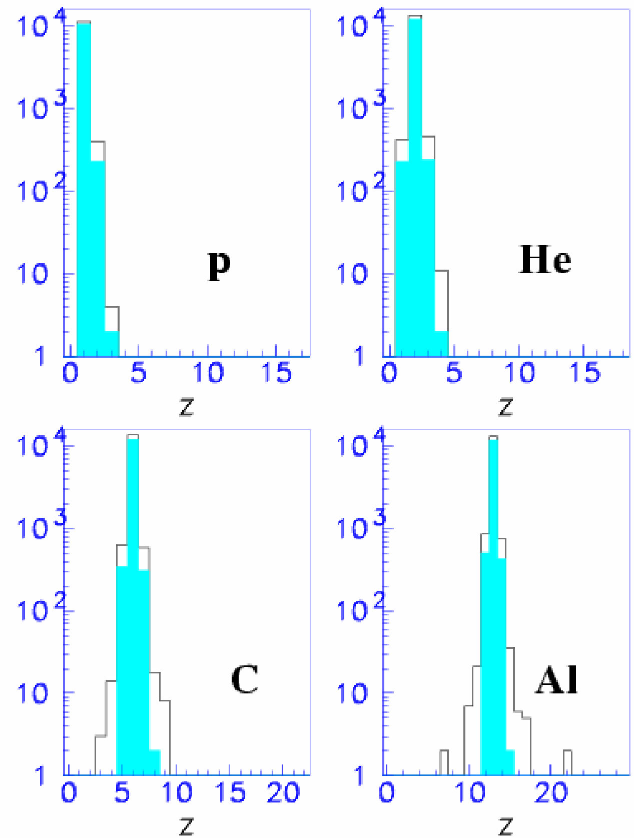
Responsible: J. Casau

– Reconstruction Algorithms (β and Z)
– MC simulation and production

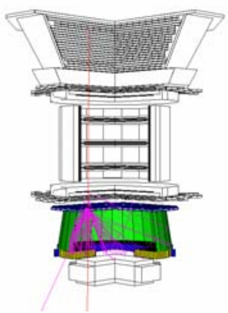
Beta resolution (MC simulation)

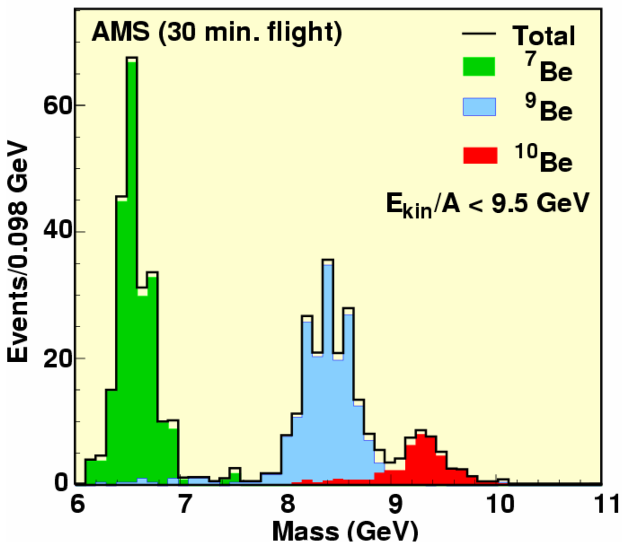


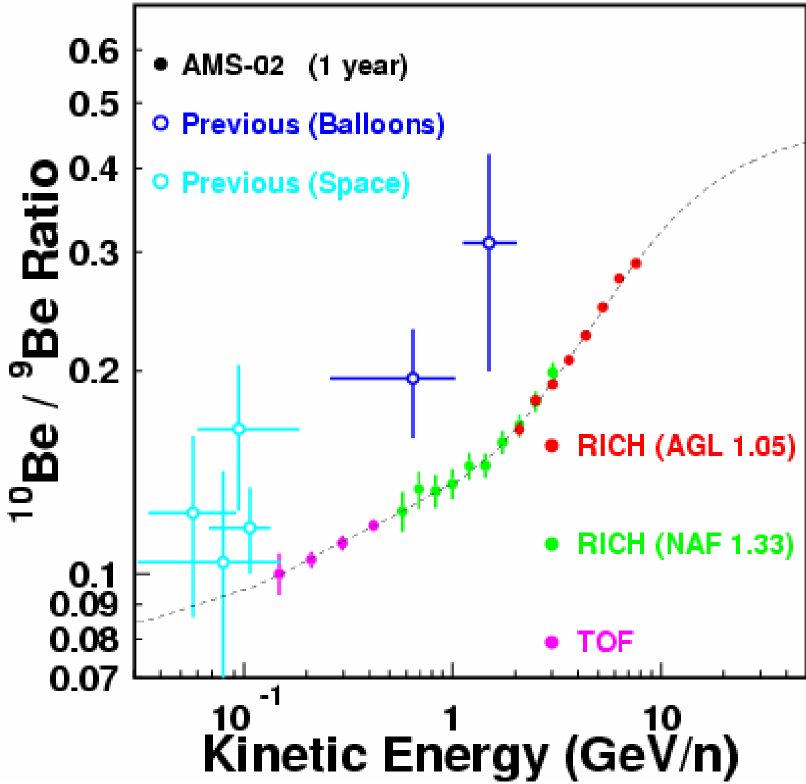
Charge reconstruction (MC simulation)



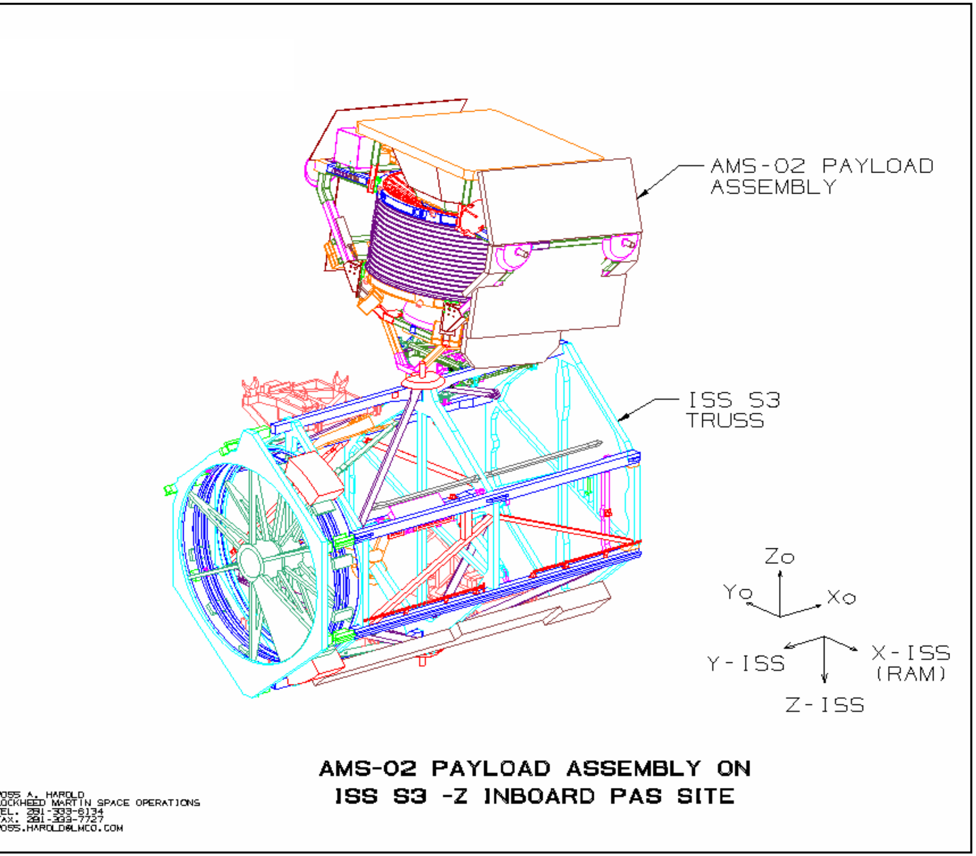
An example of the Physics Capabilities: $^{10}Be/^{9}Be$







Long term tasks



Long term Activities (2004-2008)

- Integration and functional test of the Experiment at ETH (Zurich)
- Thermal Vacuum test at JSC
- Integration and commanding operations procedures at KSC
- Launch (2005)
- Commanding and monitoring
- Data taking and analysis

Superconductivity

CIEMAT-CEDEX Group: Applied Superconductivity

(Activities related to the field of Particle Physics)

Since 1989 this group has been very active in the design, fabrication and testing of magnets for particle accelerators:

Several Superconducting Magnet prototypes for the LHC.

Fundamental role in technology transfer to industry: 2000 correcting magnets for the LHC being produced by a spanish firm.

Conceptual design of magnets, and associated devices, for TESLA 500. Two prototypes of Superconducting Quadrupoles produced.

R&D in current leads using High Temperature Superconductor technologies and also in new materials for High Field magnets.

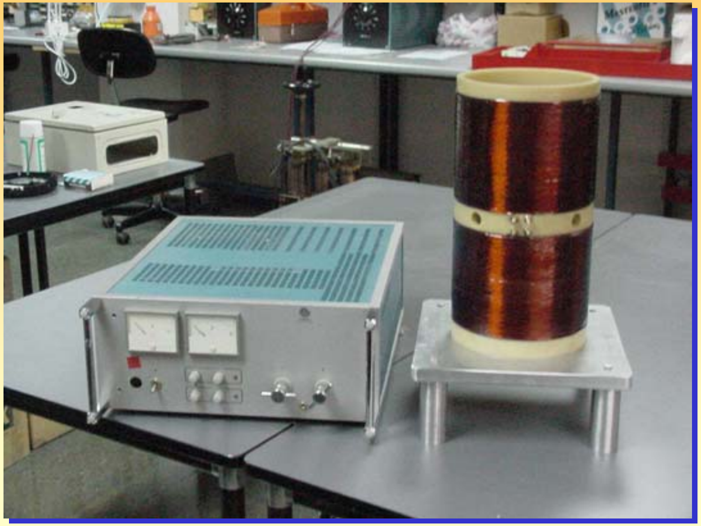
Participation in the design and follow up of the fabrication of the AMS Superconducting magnet power supply.

MQTL prototype

Applied Superconductivity Group – Status Report 2002

Design and fabrication of two prototype combined superconducting magnets for TESLA500.

Participation in AMS-02:
• Power supply fabrication follow-up
• Design and fabrication of a copper solenoid for magnetic shielding tests



Support to other HEP Groups

1. Universidad de Santiago de Compostela

   DIRAC at CERN PS (Electronics for MSGCs)
   GSI (Electronics for RPCs)

2. Universidad de Granada

   ICARUS (Muon Spectrometer)
   Under discussion

Summary

- Since the last RECFA review in 1997, significant increase of resources (human and material) have been achieved.

- L3 has been successfully completed.

- Resources strongly focused on CMS and AMS to fullfil our commitments in time.

- Looking forward to 2005 (AMS) and 2007 (CMS) to get physics started.

- Willingness and determination to get involved in new challenging opportunities, assuming the present support is maintained.

The Particle Physics Group at CIEMAT

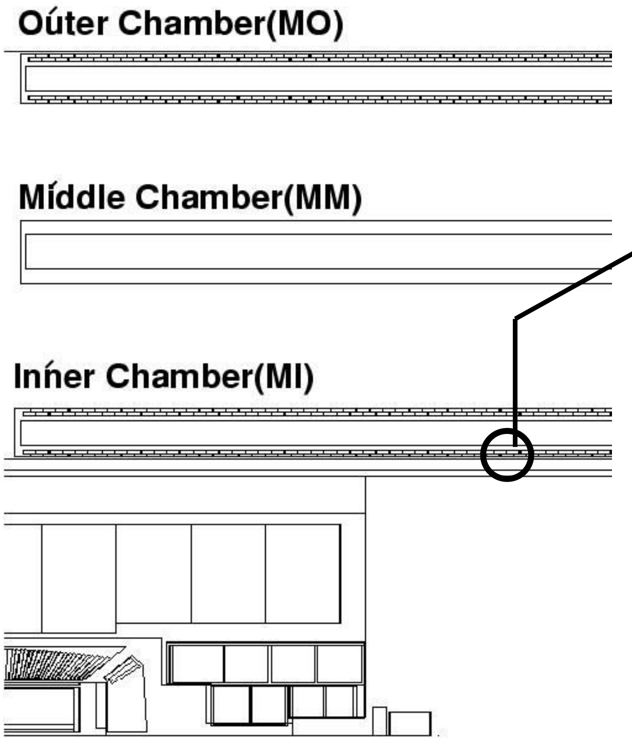
Brief historical background:

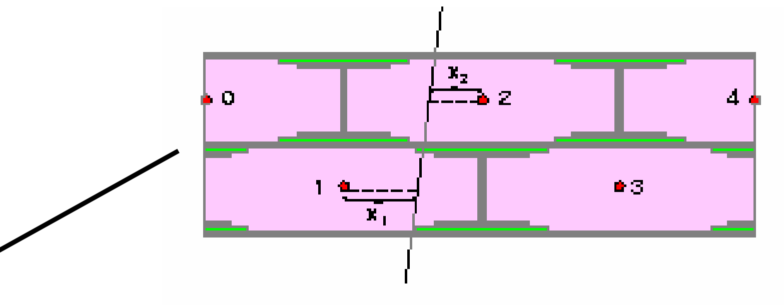
- Experimental High Energy Physics activities at CIEMAT started in the 1960´s (bubble chamber experiments).
- The transition to fixed target hybrid experiments took place when the group joined the EHS Collaboration.
- Participation in collider experiments started at the beginning of the 1980´s. We joined UA1 and MARK-J Collaborations.
- Spain becomes again a CERN member state in 1983. This was very important for the consolidation of our group (already involved in the L3 experiment at LEP) and for the whole high energy physics community in Spain.
- A new line of activity opened after joining the AMS experiment. In 2000 Astroparticle Physics became a separate CIEMAT project.

EVOLUTION of RESOURCES (Material and operating budget) In Keuros

	95	96	97	98	99	00	01	02	03	04	05
L3	90	90	85	90	85	92	82	82			
CMS	192	300	310	450	480	590	640	705	710	610	510
AMS			64	64	64	565	768	1105	1076	1042	1042
FAST									30	40	30

Construction of Z chambers



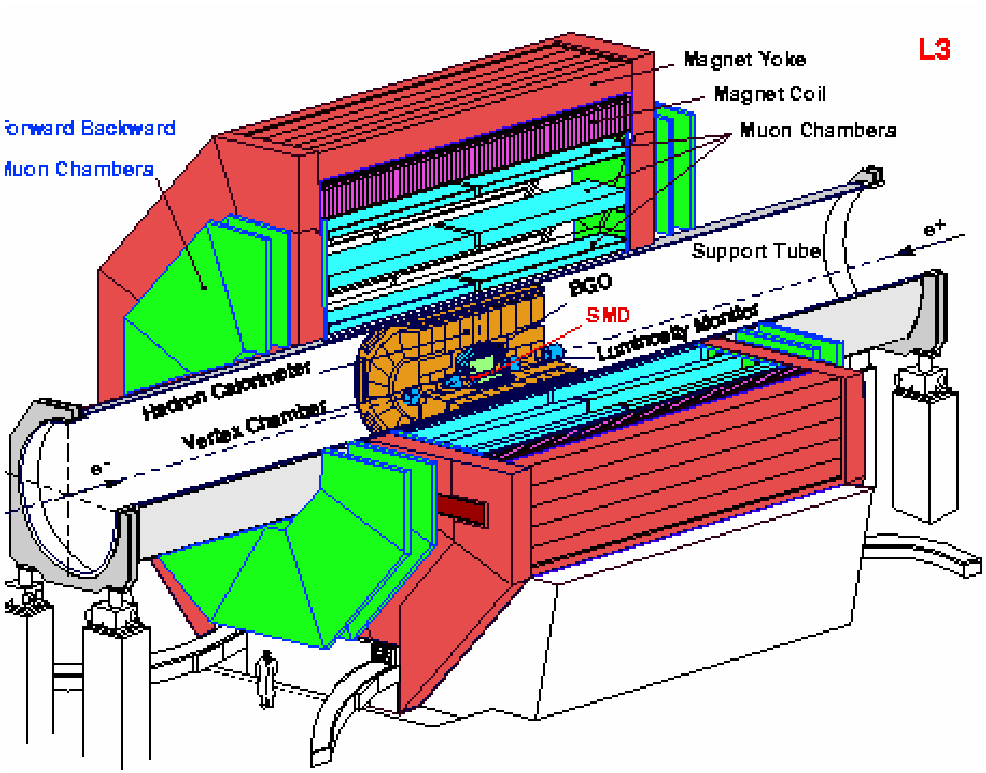


- Measurement of muon trajectory coordinates along the Z direction

- Construction at CIEMAT of 96 chambers with typical dimensions 6x2.5 m^2 (in total 12000 wires). Important contribution from the Engineering and Electronics Groups and Mechanical Workshops.

- Finished as scheduled, their performance has been fully satisfactory. They have been in operation with minimal maintenance during the 12 years of LEP data taking.

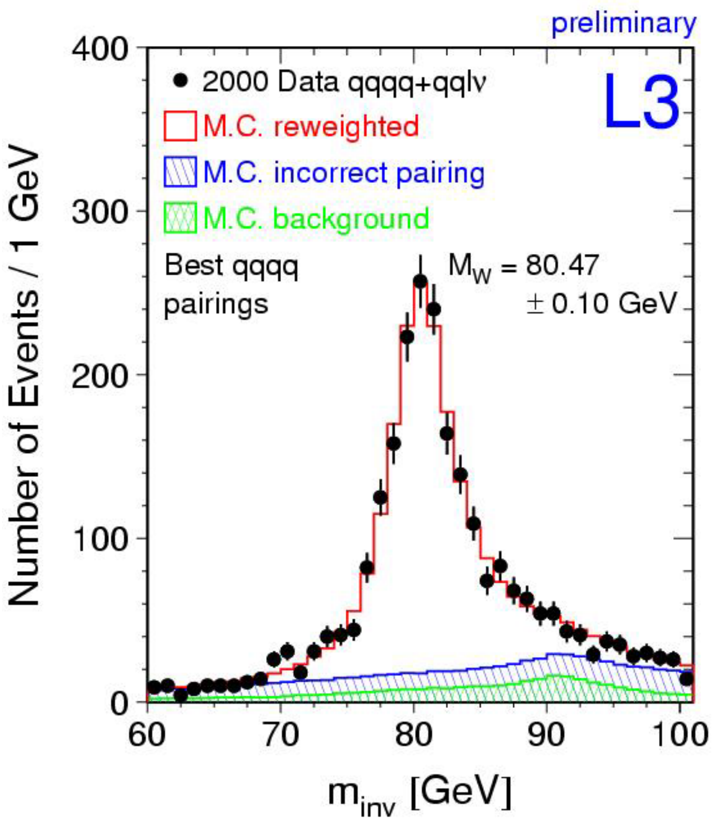
L3 Forward-Backward Muon Chambers (LEP2)

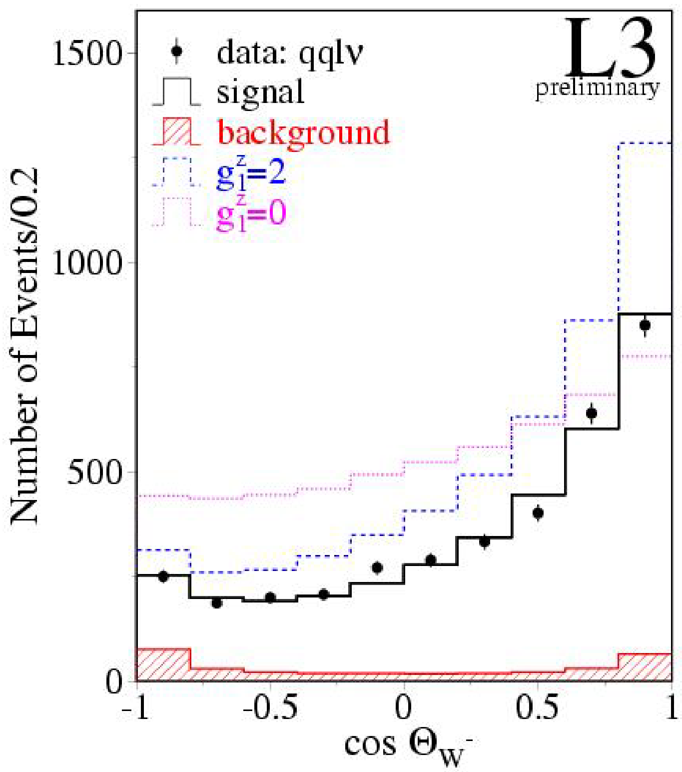


CIEMAT contribution:

- Precision templates for wire positioning
- Alignment system to monitor relative position between the Barrel detector and the Forward Backward chambers.

LEP2 Physics





Work is still going on to improve the measurement of W mass and its systematic error.

Many predictions beyond the SM manifest as deviations in the WW differential cross section. The data show a perfect agreement with SM.

Short summary of CIEMAT contribution to R+D phase in Barrel DT chambers

1) Small size prototypes

- contribution to chamber design
- develop assembly procedures
- contribution to assembly tools design
- detailed study of drift cell
- behaviour under magnetic field (test beams 96 and 97)

2) Changes to TDR design

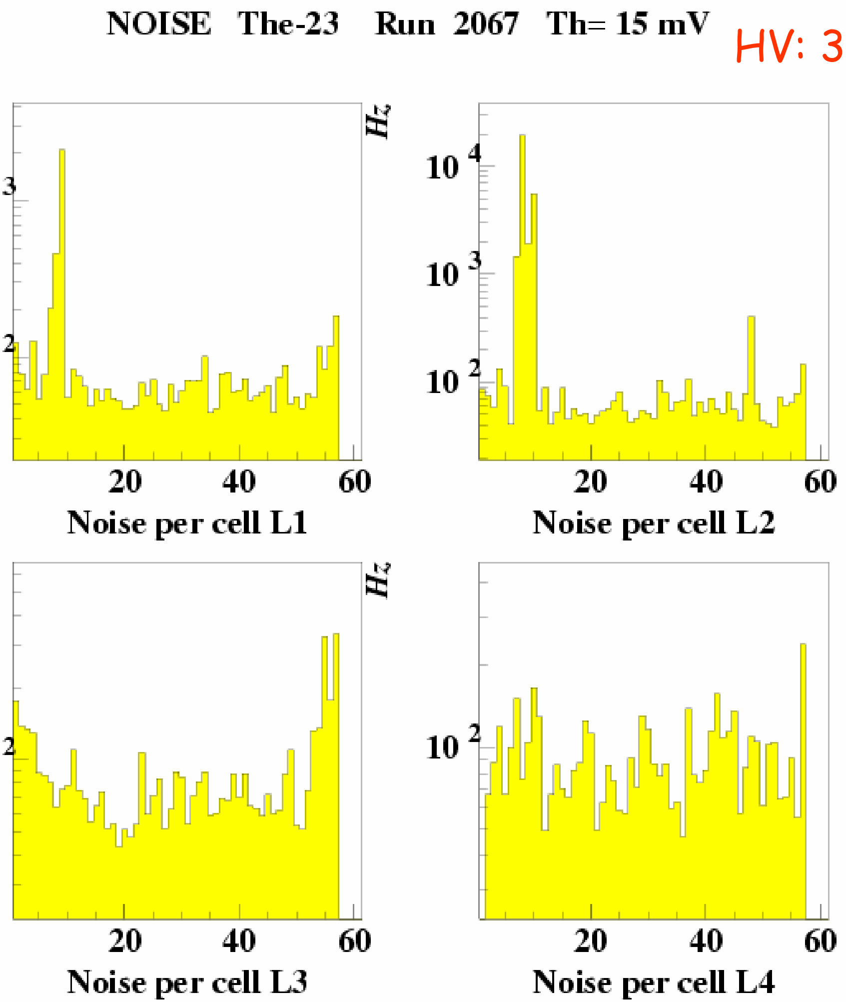
- study of the new cell configuration
- redesign basic chamber components

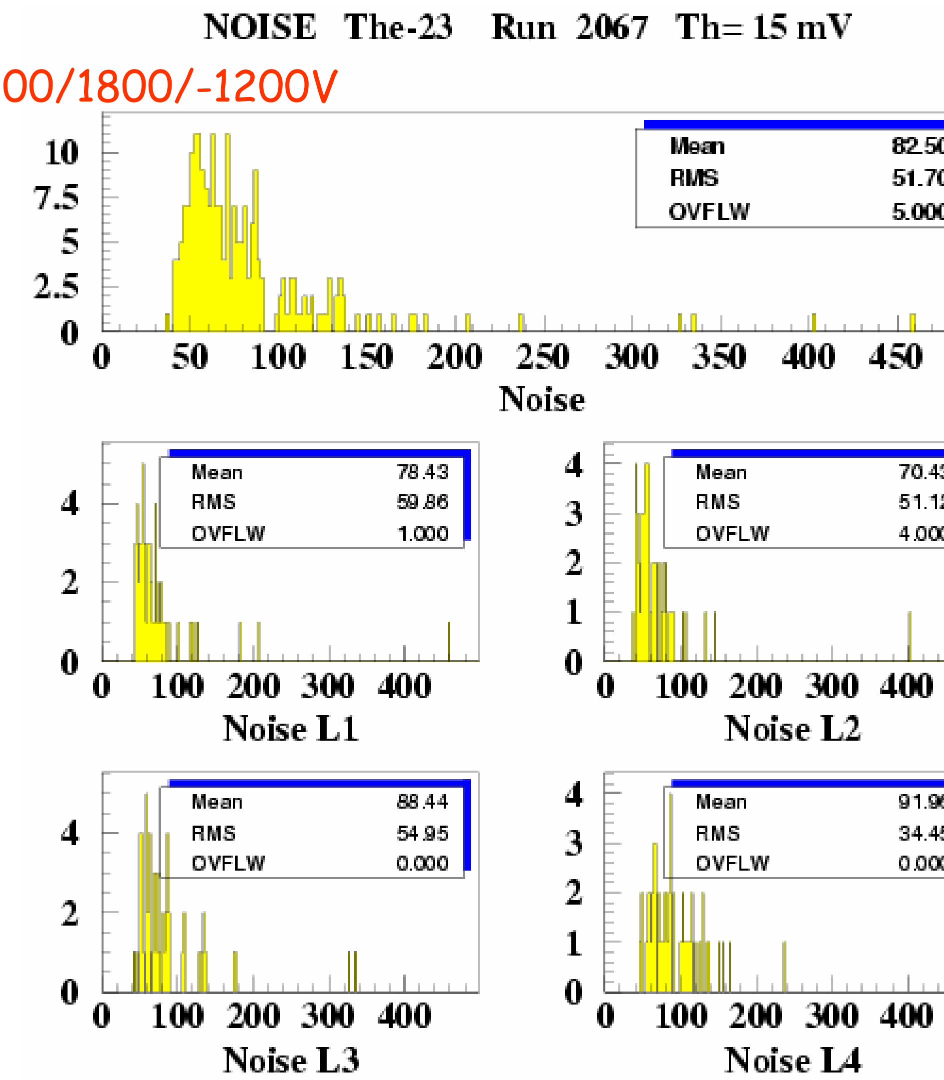
3) Q4 prototype

- test final design and final assembly tools and procedures
- test chamber performance and
  define best operating conditions (test beams 99 and 00)
- green light to start chamber production

NOISE RESULTS

HV: 3600/1800/-1200V





Noise < 100 Hz (It includes cosmic rate)

Noise Cells (>1kHz) < 1 %

Summary of chamber production milestones

a) First chamber finished (MB2 (1)) (January 2001)

b) MB2 (1) transported to CERN (June 2001)

c) MB2 (1) tested at CERN (ISR hall) with cosmics (July 2001)

d) First test of coupling DT-RPC (MB2 (1) - RB2 (1)) (August 2001)

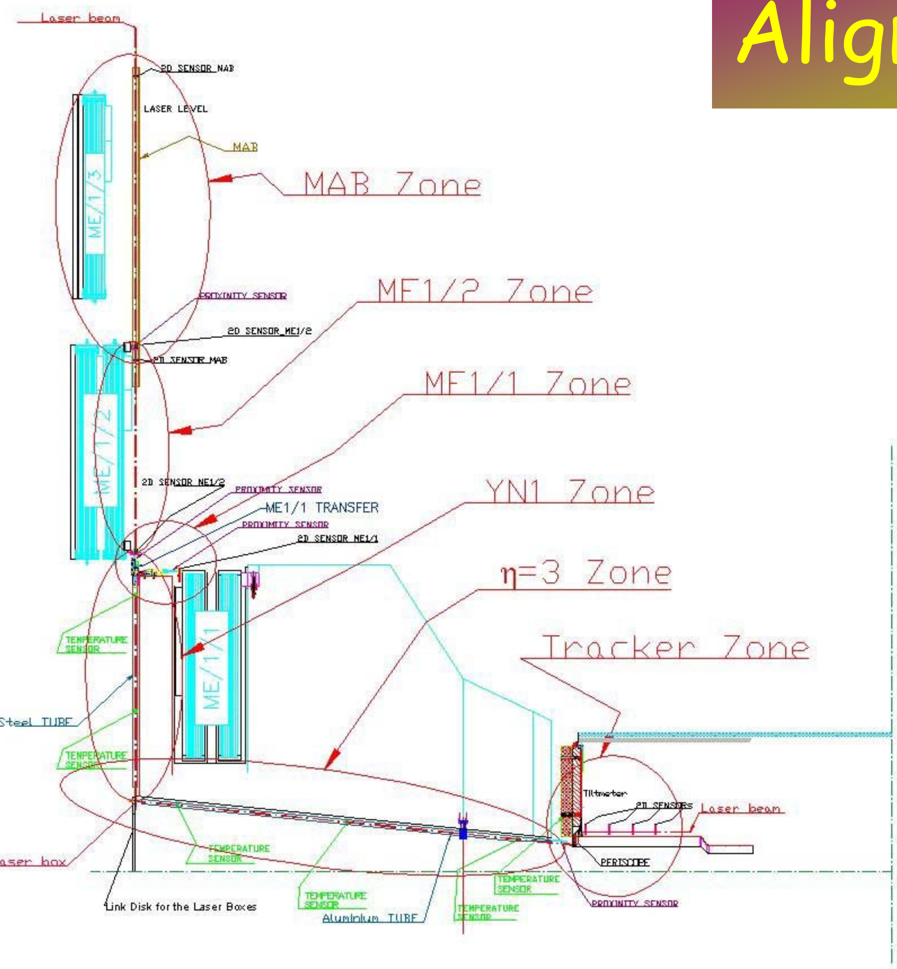
e) Test beam at GIF (Muon beam + gamma ray source) (September 2001)

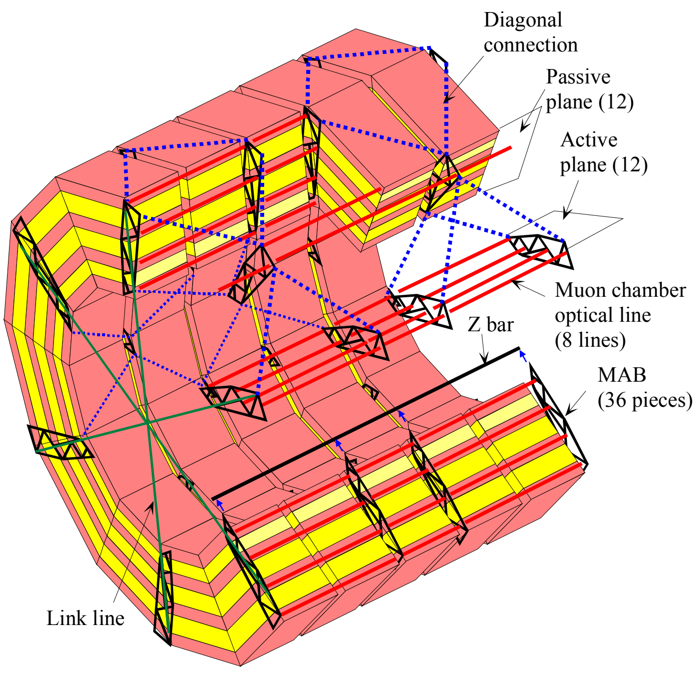
f) 24 SL's (corresponding to 8 chambers) assembled at CIEMAT by the end of 2001 (~10% of total number)

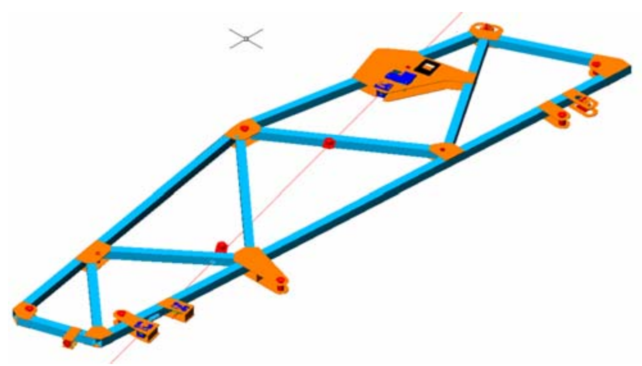
g) First test of MB2 chamber insertion in the yoke (August 2002)

h) 72 SL's (corresponding to 24 chambers) assembled at CIEMAT by the end of 2002 (~35% of total number)

Alignment







Alignment precision required

(Barrel and Endcap detectors)

- **rϕ coordinate: Barrel: 150 (350) μm MB1 (MB4)**
  Endcap: 150 μm ME1 layer
  430 μm CSC 2,3,4 layers
- **r & z coordinates: at the mm level**

Muon Trigger: DT Track Finder (with IHEP-Vienna)

✓ Responsibility for Look-Up-Table (LUT) generation and maintenance.

✓ 2002 Calculation of patterns in the r-η view: necessary for VHDL board design: Note in preparation

✓ 2002 Calculation of DTTF extrapolation LUTS: new extrapolations found useful. Necessary for prototype testing: Note in preparation

Muon Trigger: DTTF Online Control Software

✓ Plan is to set-up and operate testbench with DTTF configuration for software development at Madrid.

✓ Got space and basic infrastructure at UAM. Identifying postdoc candidates.

✓ 2002 Provided code for control of DTTF prototype tests at CERN.

Hadron Calorimeter in Muon trigger

✓ Hadron Outer (HO) compartment provides confirmation for rate reduction of RPC muon trigger.

✓ 2001-2 Conceptual design worked out for HO + RPC combined trigger → 1 Note

✓ Proposal officially approved in February 2003:

HO is now part of the CMS L1 Trigger Baseline

Test of DT chambers at CERN (with CIEMAT)

✓ 2001-2 Participation in test of chambers and related electronics using cosmics and test-beam data → 2 Notes

✓ Plan to continue in next years.

Particle Physics Phenomenology

✓ 3 PRD articles published in 2002.

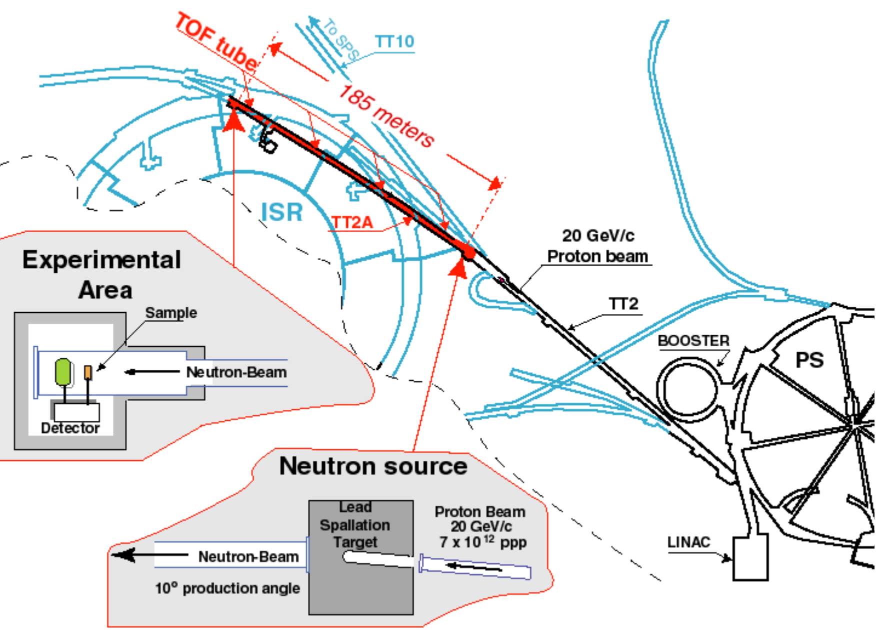
✓ Immediate goal is CMS Physics TRD (2004).

nTOF

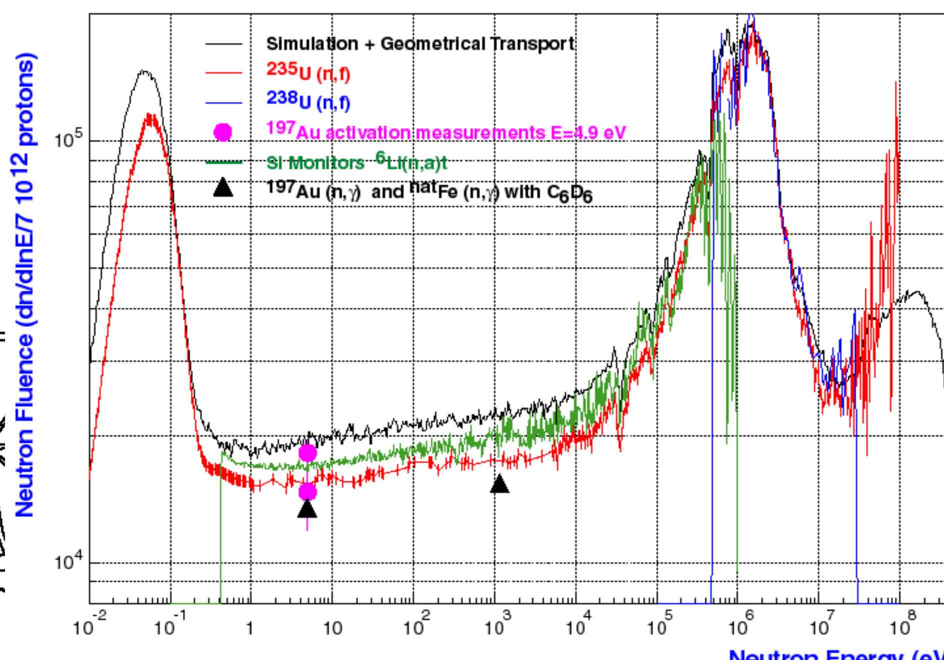
The objective of nTOF is to measure, analyze, evaluate and distribute the nuclear cross sections required for Nuclear Waste Transmutation, the Thorium Cycle and the ADS design. The experiment is partially financed by a FP5 EU project and for the Spanish participation by the Ministry of Science and Technology and by ENRESA.

Most of the measurements are and will be performed in a facility built at CERN for this purpose with the most advanced detectors and DAQ, and providing the most instantaneously intense neutron source, with high resolution, low ambient background and reaching energies above 250 MeV.

The project also includes measurements of interest for nuclear astrophysics and basic nuclear physics



nTOF Neutron Fluence (PRELIMINARY)



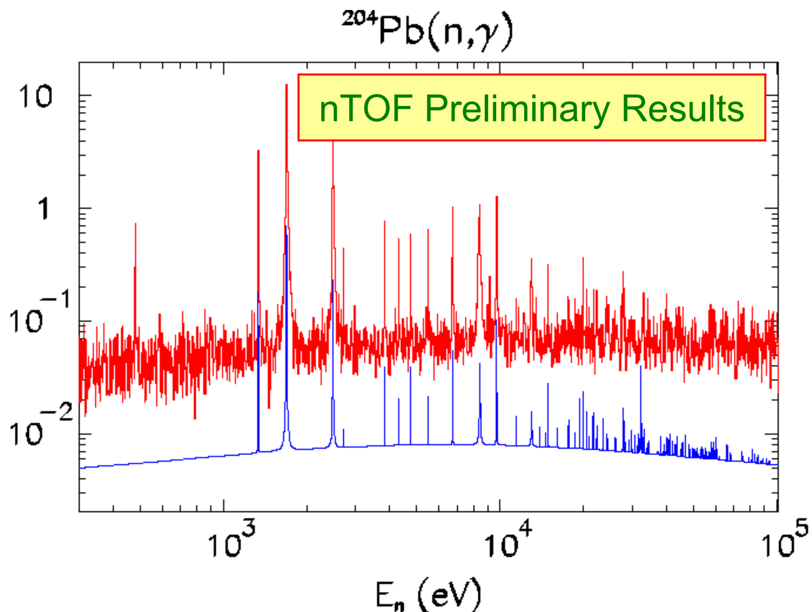
The CIEMAT Facet group has been responsible for the design of the collimation and shielding system, the general Monte Carlo of the facility, the DAQ design and Fast Analysis system and has participated on the capture detectors. CIEMAT is also deeply involved on the total absorption calorimeter

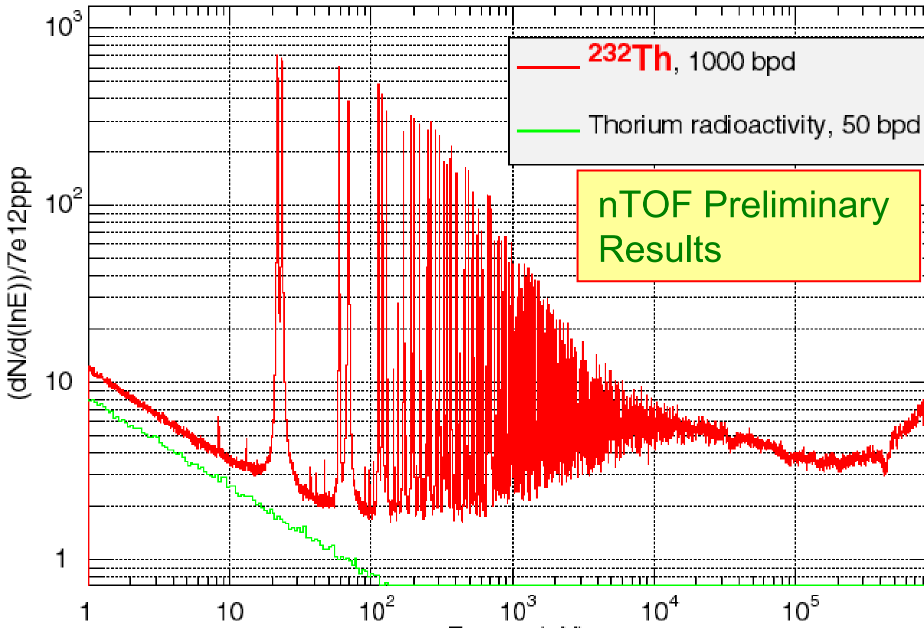
Furthermore, CIEMAT is the coordinator of the capture cross section measurements of the transuranium actinides.

5 additional Spanish institutions participate on the nTOF experiment:

CSIC – IFIC (Valencia): deeply involved in all capture measurements
U. Santiago de Compostela: that participates on the neutron beam monitoring and fission measurements
U. Politécnica de Cataluña: contributing to the Monte Carlo simulation and data analysis
U. de Sevilla: That has develloped nuclear models and participates on the cross section evaluation
U. Politécnica de Madrid: with contributions to the experiment simulation

There are 2 Expressions of Interest for the continuation of the nuclear data measurements for transmutation fuel cycles and devices. The FACET group is the coordinator of one of them. We are trying to join the two proposals before submission to the FP6

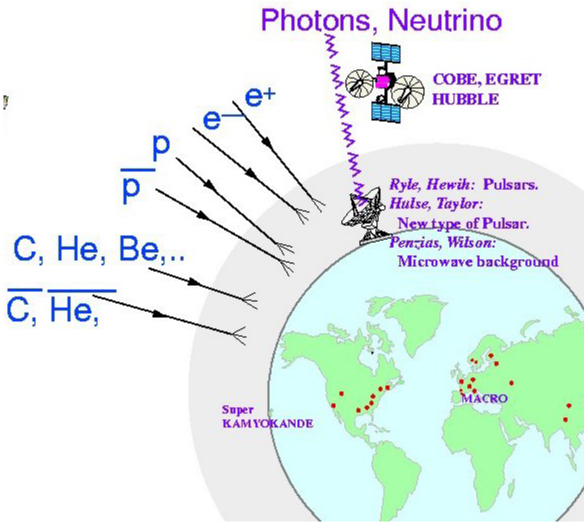




Introduction

- Astroparticle Physics is a field overlapping with High Energy Physics and Astrophysics

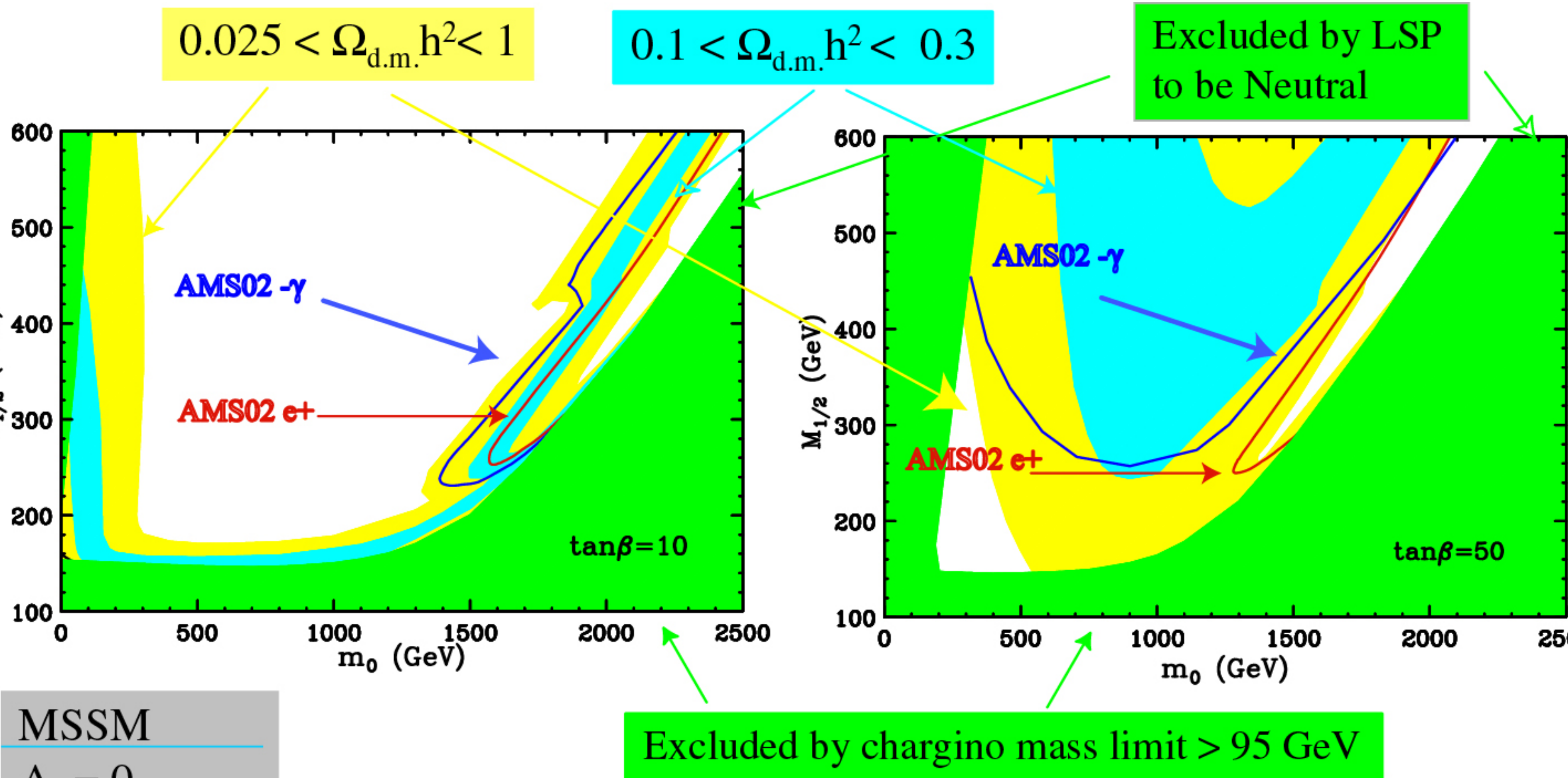
- The Experimental Research is based on measurements on cosmic radiation with ground-based detectors, balloons and satellites



❖ CERN recognized Experiments
- Cosmic ray Experiments:
  - -ground-based: (L3+C, AUGER PROJECT)
  - -Balloons (CAPRICE)
  - -Satellites (PAMELA)
  - -ISS (AMS)
- Gamma ray Experiments (GLAST)
- Neutrino Experiments (ANTARES, NESTOR)
- Gravitational Waves (EXPLORER, LISA)

- Cosmic Rays (AGASA HiRes, BESS, ACCES
- Gamma Rays (EGRET, MAGIC)
- Neutrinos (SuperK, AMANDA)
- CMB (Boomerang, DASI, WMAP)
- Gravitational Waves (LIGO, VIRGO)

Example of AMS sensitivity to SUSY Dark Matter



MSSM

$A_0 = 0$

$\mu > 0$

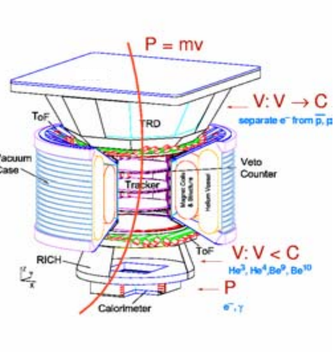
$m_t = 174$ GeV

$\tan\beta = 10$

Fixed Halo profile, indirect limits better if halo is clumpy

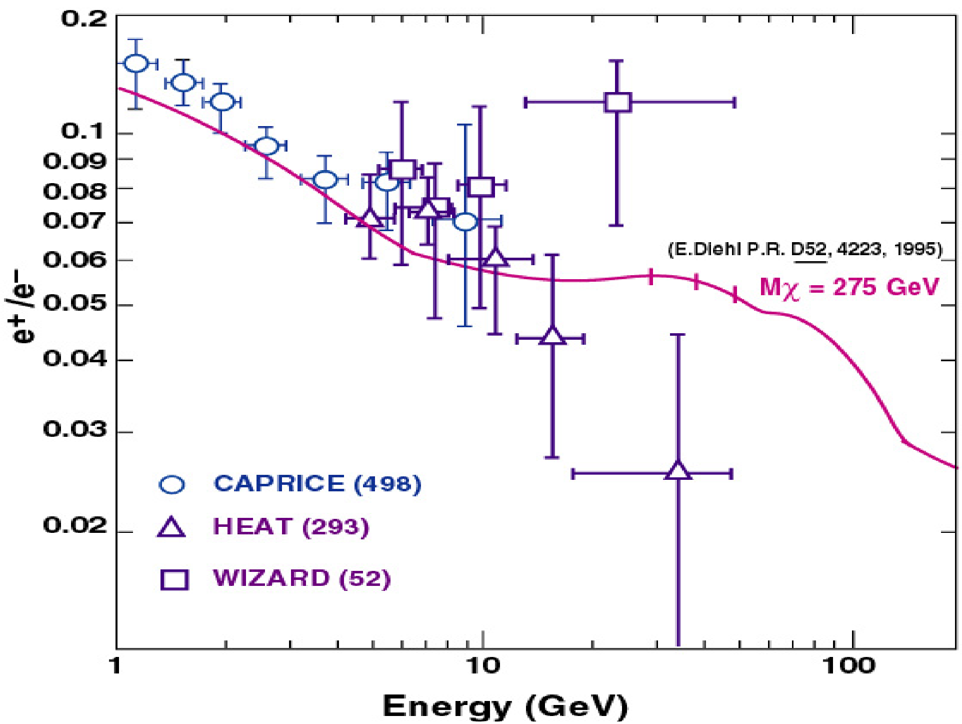
adapted from astro-ph 0008115

AMS02: Expected performanes

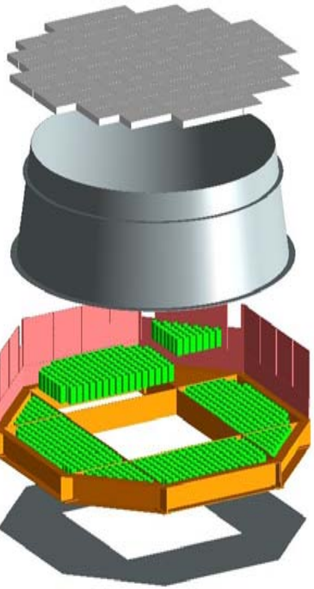


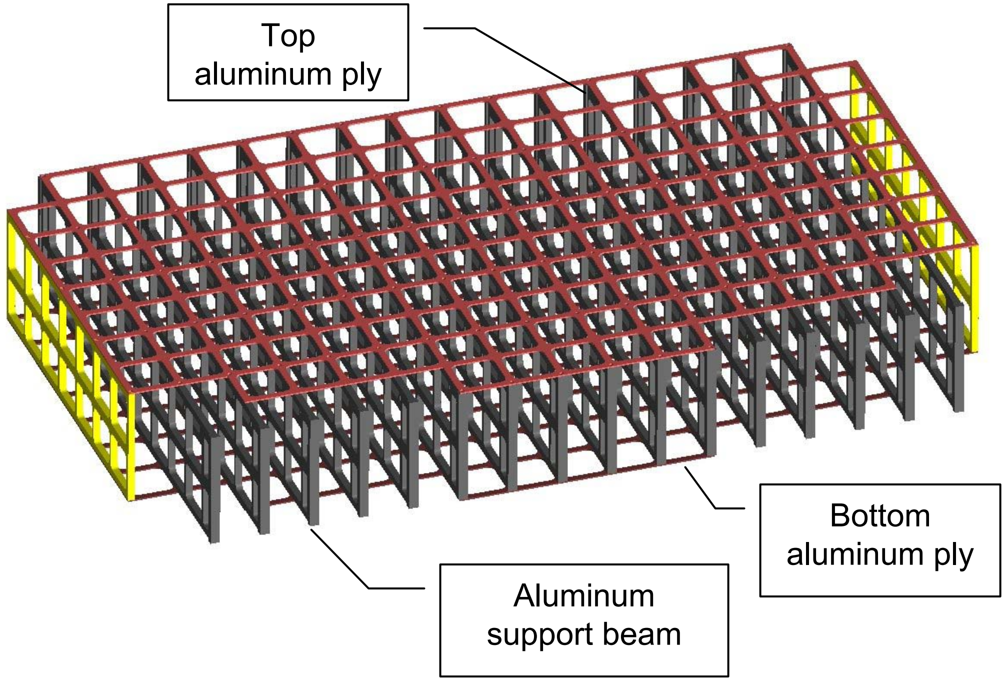
article ype	Energy range
	~ 1 TeV
e,….C	~ 1 TeV
ght sotopes	10 GeV/n
	200 GeV
	200 GeV
nti – e,…C	~ 1 TeV
	~ 1 TeV
	300 GeV

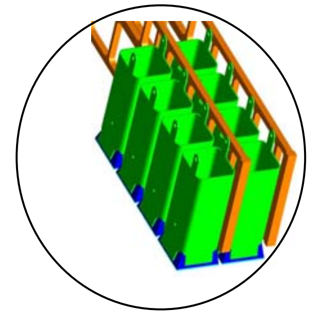
Positron to Electron ratio



RICH Mechanics

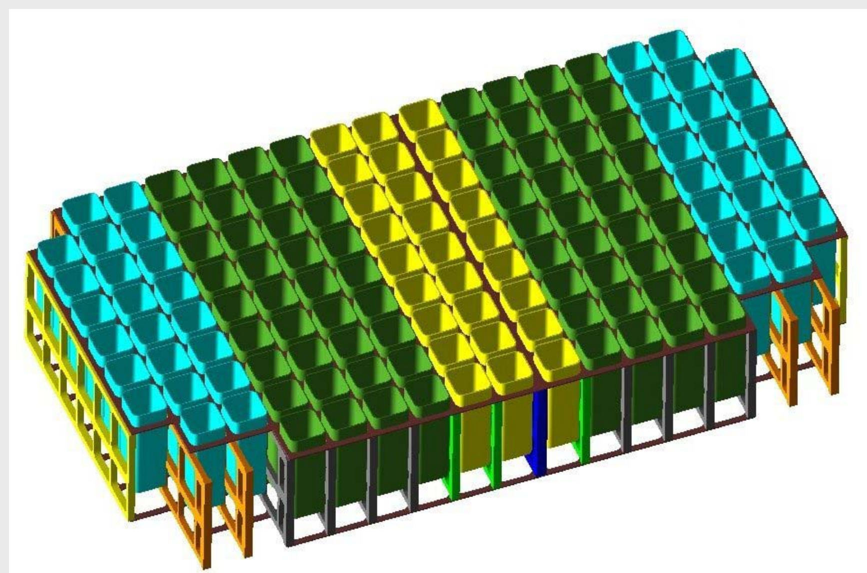




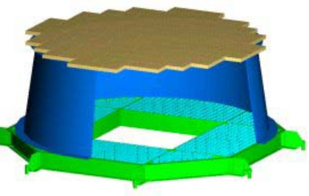


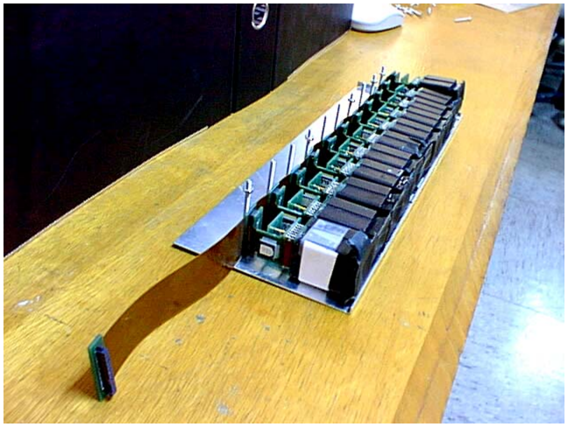
B ~ 300 G

Th. = 0.8 mm
Th. = 1.0 mm
Th. = 1.2 mm



RICH Electronics Parameters





Main parameters of the RICH Read Out Systen

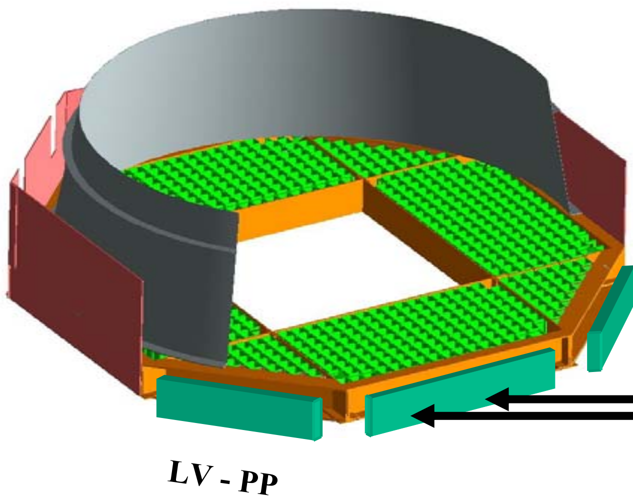
GRANULARITY:
- 31 PM's per Control Board

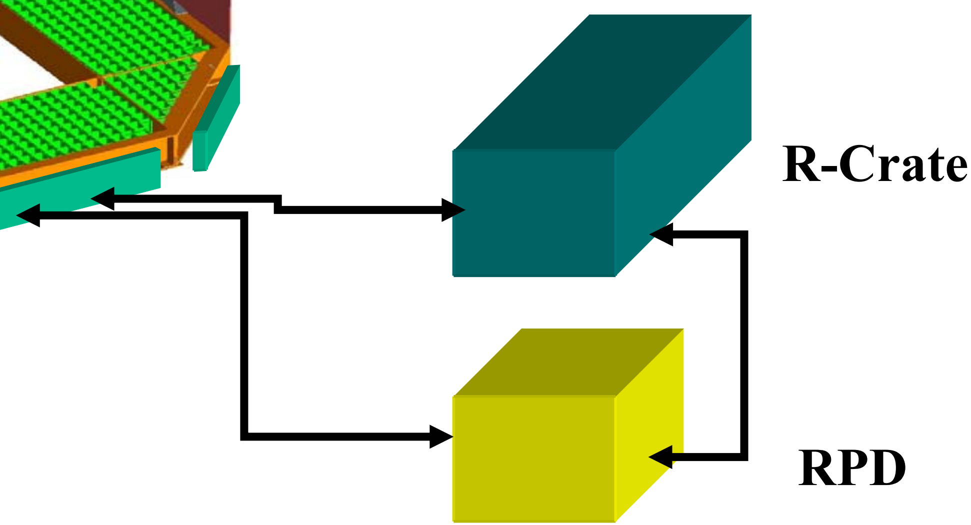
TRIGGER RATE:
- 2KHz Trigger Rate

TIMING:
- 2 μs Acquisition time
- 64μs Dead Time per Event
- 300μs Worst Case Processing Time per Even

OTHERS:
- 100 Mbits/s Data transfer rate to main DAC
- 4 Events input buffers

OPERATION MODES
- Raw
- Reduced
- Calibration

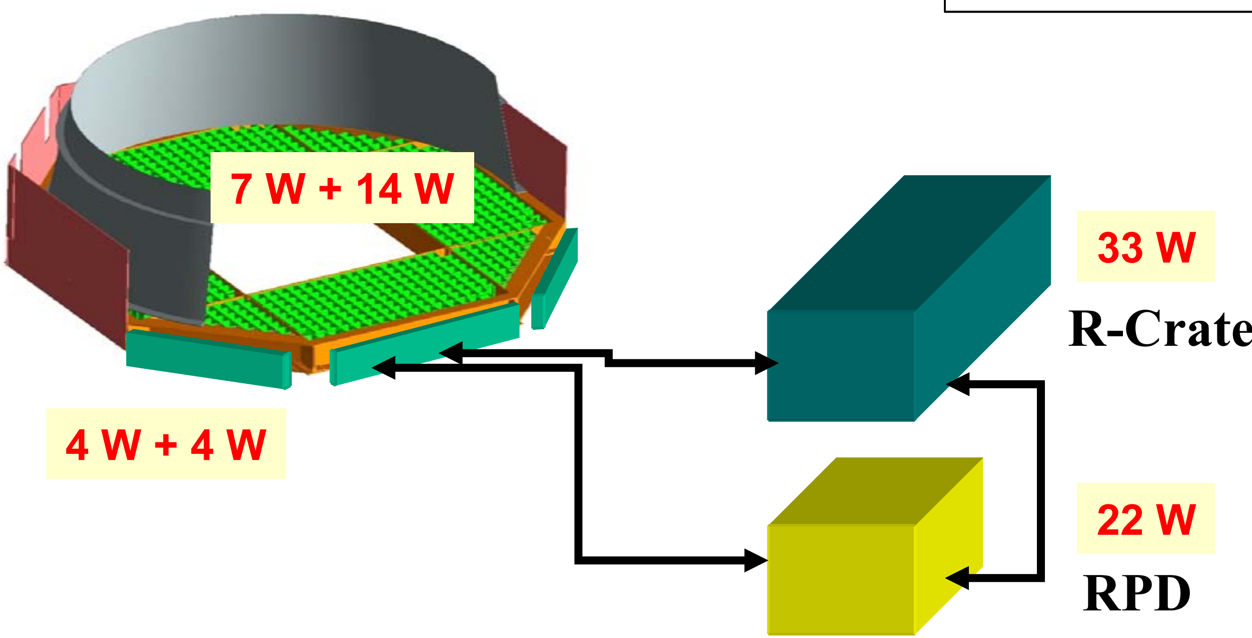




RICH Electronics Parameters (Power Consumption)

TOTAL **84 W**

- –HV inside RICH ~ 7 W = 680 PM * (900 V**2 / 80*10**6 Ohm)
- –LV inside RICH ~ 22 W = 14 (Preamp + ADC) + 4 (LVLR) + 4 (Drivers)
- –LV at R-Crates (2 Crates) ~ 33 W
  - –2 * 6 RDR2 (2 * (CDP + Drivers) ~ 24 W = 2 * 6 * 2 *(0,25+0,05) A * 3,3 V
  - –2 * 1 JINF ~ 2 W = 2 * 0,3 A * 3,3 V
  - –2 * 2 USCM ~ 3 W = 2 * (0,2 Hot + 0,02 Standby) A * 5 V
  - –2 * 2 HV Control ~ 1 W = ?
  - –2 * 2 HV Bricks (0,7 Eff) ~ 3 W = 6,88 / 0,7 - 6,88
- –LV DC-DC (0,7 Eff) ~ 22 W = (22 + 28,94) / 0,7 - (22 + 28,94)



FAST Experiment

The goal of the experiment is the measurement of the Fermi constant to 1 ppm (10 times better accuracy than the present world average)

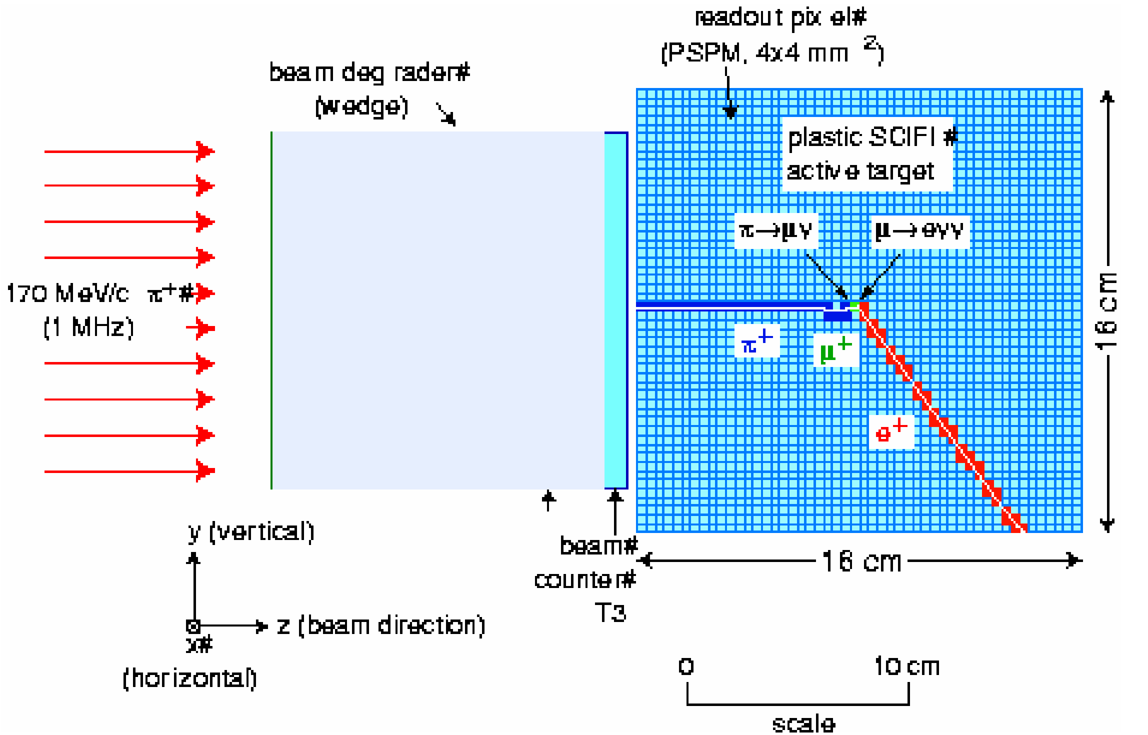
18 physicist from 5 institutes:
CERN, PSI, CIEMAT, University of Geneva, University of Nimegen

New project (98900 euros) requested to "Plan Nacional de Física de Partículas y Grandes Aceleradores" for 3 years

People from CIEMAT working on FAST:
J. Berdugo, J. Casaus, C. Mañá, J. Marín, G. Martínez, E. Sánchez

CIEMAT contributes on hardware, electronics for level 2 trigger and data analysis

FAST characteristics



BEAM:

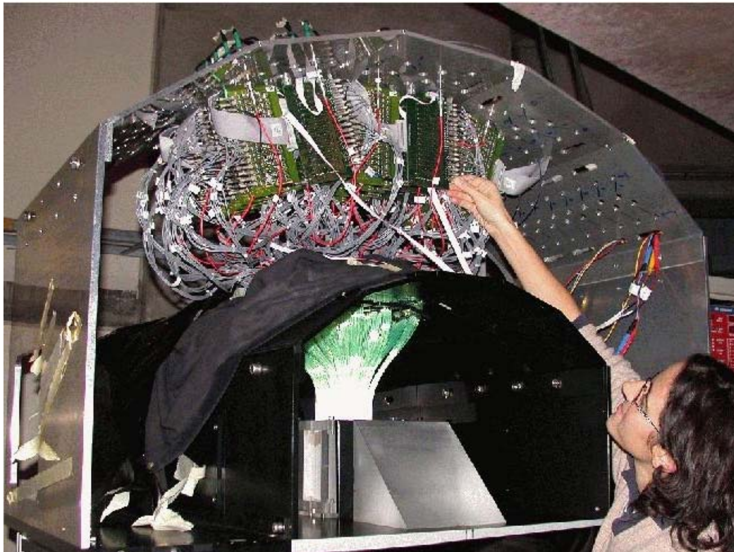
pion beam at PSI
p = 170 MeV/c (3%)
size = 10x16 cm^2
rate = 1 Mhz
purity = 90%

TARGET:

40x40 scintillator "baguettes" of 4x4x1600 mm^2
(25 p.e./pixel for a mip)

READOUT

100 PMT's with photocathode of 4x4 pixel



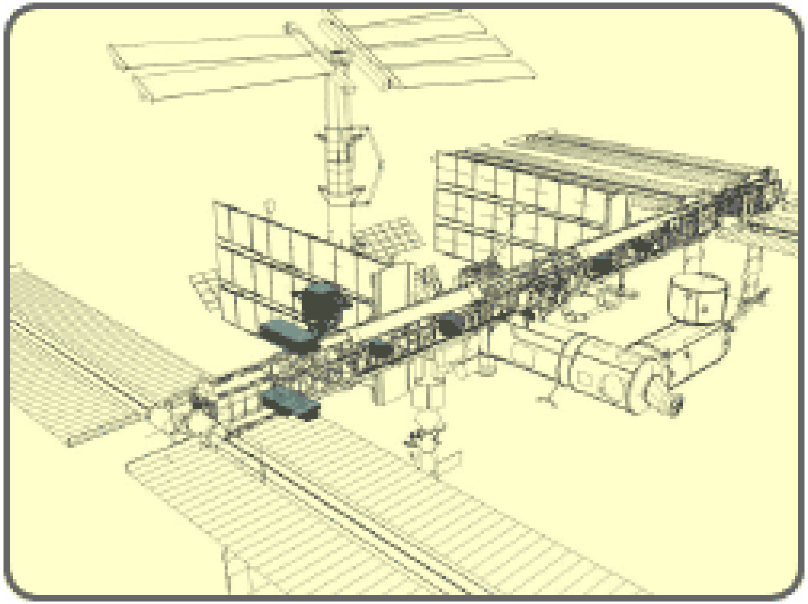
FAST schedule

Experiment approved at PSI	2000
Prototype test, re-design of DAQ	2001
System integration test at PSI	2002
Installation and check out	2003
Data taking	2003-2004

The AMS Experiment

The purpose of the AMS Experiment is to perform accurate and high precision primary cosmic ray measurements in the space.

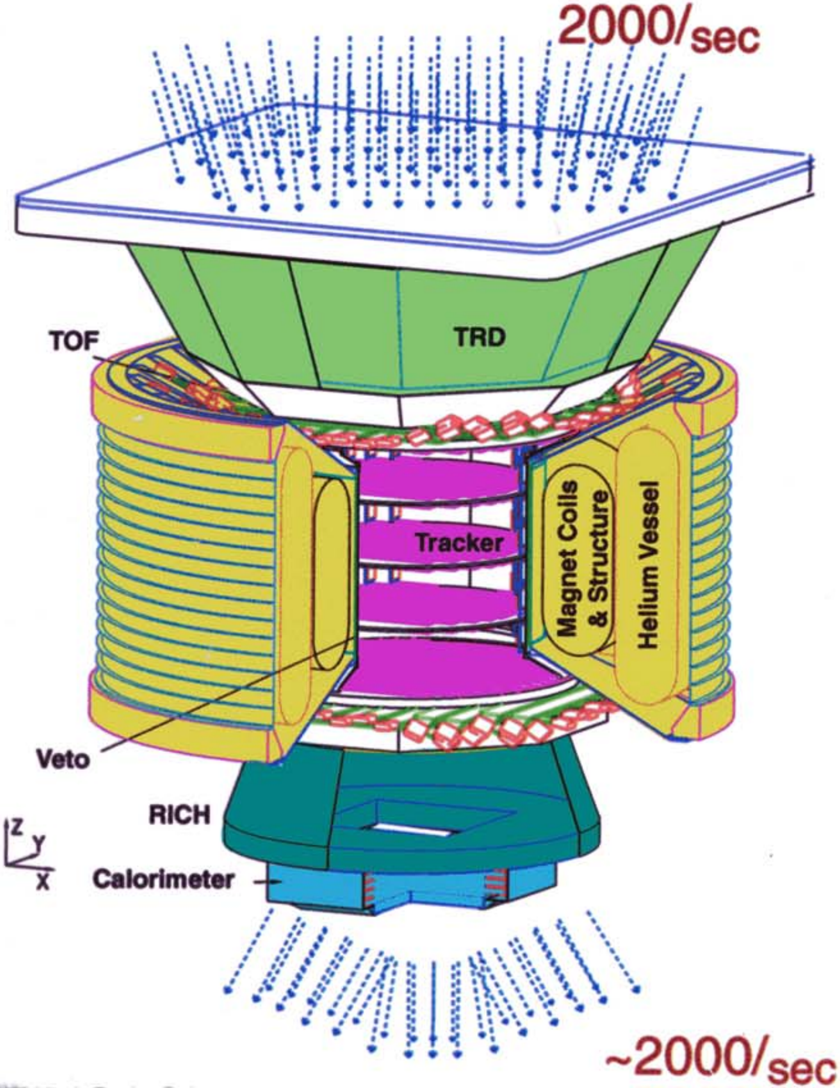
A particle detector will be placed for a 3-year period on the International Space Station (ISS).



- The detector will have capabilities to identify the cosmic ray nuclei with $Z \leq 20$ and to measure their energy spectrum up to the TeV region.

- The International Space Station (ISS) is a unique platform for accurate measurements of cosmic rays
  - ISS is orbiting at 400 km altitude (background free) covering a broad range of geomagnetic latitudes.
  - ISS provides the needed infrastructure to operate a multipurpose detector (Power, Weight and Long Exposure period)

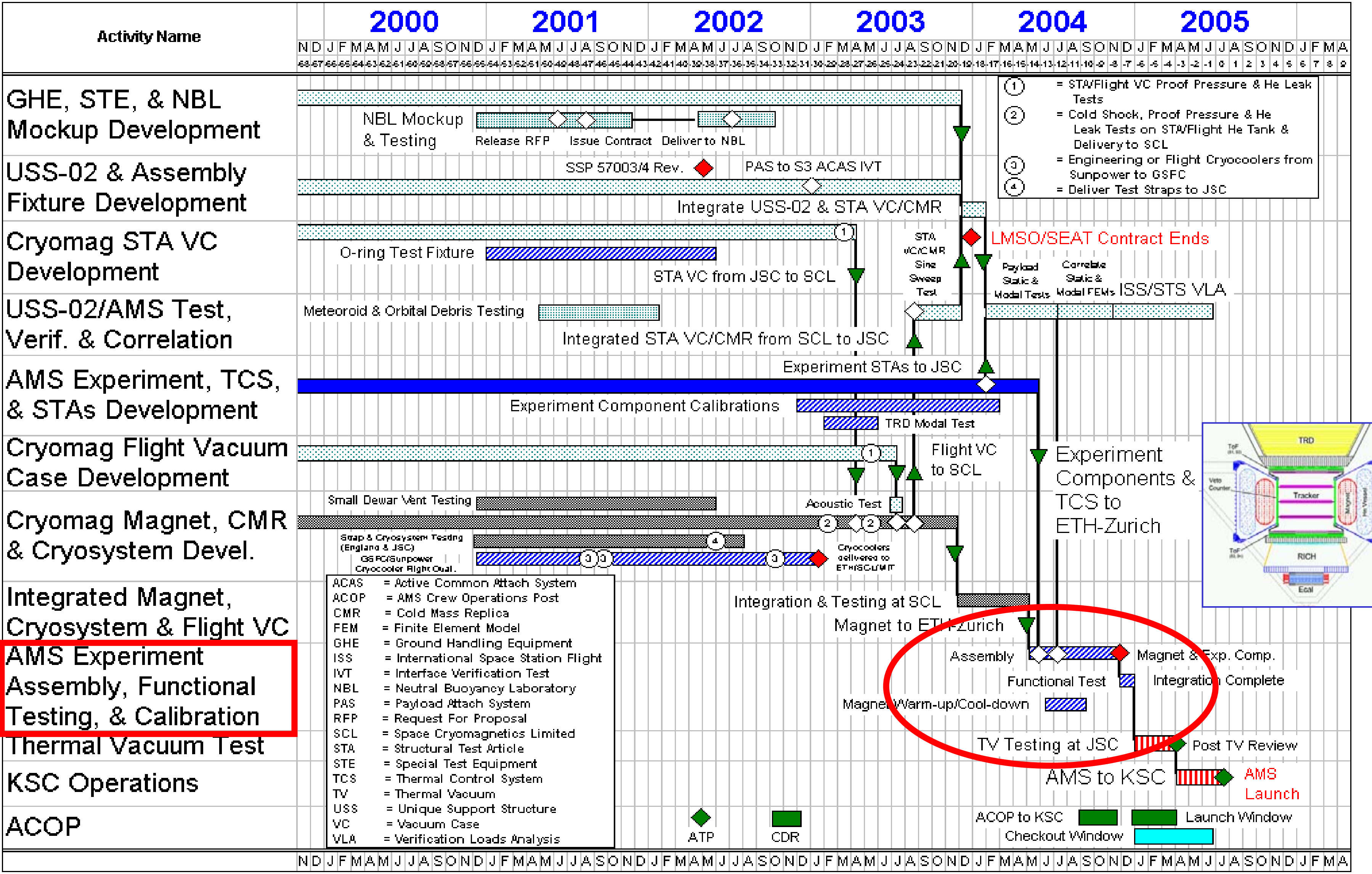
AMS: A TeV Magnetic Spectrometer in Space

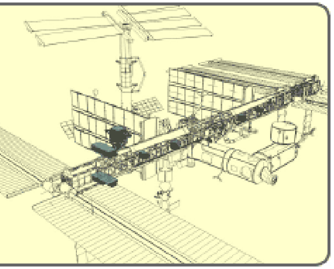


300 GeV	e^-	e^+	P	$\overline{He}$
TRD				
TOF				
Tracker				
RICH				
Calorimeter				

AMS02 Schedule

AMS-02 MASTER SCHEDULE --- JULY 2005 ISS FLIGHT





Physics goals

To perform an exhaustive study of the cosmic ray composition and relative abundance of the light nuclei isotopes.

→ Astrophysics studie

Source compositi

Acceleration Mechanis

Interaction with the IS

Accurate measurements of the energy spectrum of antiprotons, positrons and photons.

→ Search for Dark Matte

Candidates coming fro

Particle Physics Extensio

of the Standard Model: SUS

$\chi + \chi \rightarrow \bar{p} +$

$\rightarrow e^{+} +$

$\rightarrow \gamma\ +$

Detection of $(\bar{D}, \overline{He}, \bar{C})$ with a sensitivity 10^3 - 10^4 better than current limits

→ Search for Antimatte

Baryon Number non conservati

CP Violati

AMS Weight and Power Budget

AMS WEIGHT BUDGET		
Experimental Hardware		**4981**
	ACC	53
	Tracker	198,5
	TOF	238
	TRD	328
	TRD Gas Supply	117
	RICH	184
	ECAL	638
	All avionic Crates	460
	Magnet	2357
	Thermal Control System	311
	Contingency	96,5
Space Shuttle Integration Hardware		**1468**
	USS	722
	Cryomagnet Vacuum Case	720
	Brackets	10
	Thermal Blankets	16
	Shutt. Int. Hardw. Continge	0
ISS Integration Hardware		**268**
	Hardware	268
TOTAL Weight summary		**6717**

AmsE Crate, Box Flight Design Summary Mar '03

(E:324 PMT, R:680 PMT, T: 192 Ladder, S: 34 ToF, 16 ACC, U:82 Mod, AST, GPS)

M. Capell 27 Mar 02

Crate xPD	Qty	Function (tot det)	Slots	Cards	USCM	CAN	28V in	Nominal Heat (W) Unit	Sum	ex-Box	Subsys	Delta (Jun'02)	CURRENT Kg Unit	Subsys	Delta (Jan'02)
E	2	ECal (324 PMT)	26	12	2	2		14.31	104.9	40.0	169	-10.6	21.35	85.3	+18.9
R	2	RICH (680 PMT)	19	11	2	2		22.19		24.0			14.77		
REPD	2	R+E power	9	11			2	15.93					6.55		
J	1	DAQ(MDC+JxIF)	22	22		4		28.31	52.3		52	-13.2	14.26	31.0	-3.0
JT	1	DAQ(Trig+JINJ)	14	7				2.57					6.97		
JPD	1	J+JT power(MDI)	15	7	2	2	2	21.43					9.72		
M	1	Monitor, AST, GPS & Laser Align.	12	12	2	2		27.64	41.7	(ASTC +GPS)	51	+36.1	8.09	12.9	+1.1
MPD	1		7	7			1	14.07					4.80		
S	4	Scint(34ToF+8ACC)	12	9	2	2		31.46	178.4	14.0	192	+73.4	10.17	59.4	+16.6
SPD	4		7	7			2	13.14					4.68		
T	8	Tracker (192 Ladder)	21	21	2	2		38.68	521.5	138.3	660	-92.1	13.46	161.8	-2.0
TPD	8		11	11			1	26.51					6.76		
TT	1	Tracker Thermal Elec. (1H1C)	8	8	2	2		3.53	5.5	(TTCS)	75	+70.8	5.70	9.3	+9.3
TTPD	1		5	5			2	1.94					3.58		
U	2	TRD (82 Module)	21	21	2	2		20.01	62.3	19.4	82	+1.4	13.46	40.3	-6.1
UPD	2		11	11			1	11.15					6.67		
UG	1	TRD Gas Elec	12	12	2	2		13.21	18.7	(UGB)	103	+69.2	7.71	12.4	-0.7
UGPD	1		7	7			2	5.49					4.68		
Other		**(most direct mount to USS)**									*(1384)*	*(135)*		*(412.3)*	
ASTC	2	Amica Star Tracker Cameras, with Support, Baffle, Cable						3.40	6.8		(M)	-8.0	3.25	8.0	-0.0
GPS	1	GPS Elec Box + 2 Antenna, Cable						2.00	2.0				1.50		
PDB	1	Power Distribution			2	2	0	250.00	250.0		250	+50.0	42.50	42.5	+7.5
CAB	1	Cryo Mag Avionics (inc shunt 1.2Kg)			0	2	2	30.00	30.0		30	-20.0	48.00	(108.0)	
CCEB	1	Cyro Cool Drivers			2	2	0	80.00	80.0	400.0	480	-39.5	6.00		
CDD	2	Cryo Dump (aka Free, Fly-Wheeling) Diodes - Port & Starb						0.00	0.0		0	-0.0	6.00		
UPS	2	CAB UPS (8 cells + BMS)						0.00	0.0		0	-0.0	12.50		
CVB	1	Cyro Mag Valves						0.00	0.0		0	-0.0	17.00		
C-cabling		inc current leads (2*0/2 to magnet+1*0/2 to CDDs=9.5), etc											27.50		
TTCS-P	1	Tracker Thermal **inc 50W preheat** NOT Elec. Primary						70.00	70.0		(TT)		40.00	(40.0)	
TTCS-B	1	Tracker Thermal **inc 50W preheat** NOT Elec. Backup						0.00	0.0				40.00	(40.0)	
UGB	1	TRD Gas Boxes S + C, **inc 70W peak** local heaters						84.00	84.0		(UG)		105.00	(105.0)	
Cables		intercrate												50.0	0.0
Mounting		removed end walls												-11.0	0.0
				Cards	**USCM**	**CAN**	**28V in**								
Totals	**57**			**539**	**48**	**54**	**31**				**2,144**	**+118**		**502**	**+42**
Control							**32**				**2,000**			**460**	

AMS RICH Description (1/2)

AMS RICH Collaboration: CIEMAT (Madrid), INFN (Bologna), ISN (Grenoble), LIP (Lisbon), UMD (Maryland), UNAM (Mexico)

- Size: 50 cm height, 160 cm diameter
- Weight < 200 Kg
- Power ~ 80 Watt

Radiator

- 3 cm of Aerogel (n ≈ 1.03)
- 5 mm of NaF (n ≈ 1.33)
- $N_{p.e.} \approx 10$ (for Z=1; β=1)
- $\beta_{thershold} \approx 0.751$

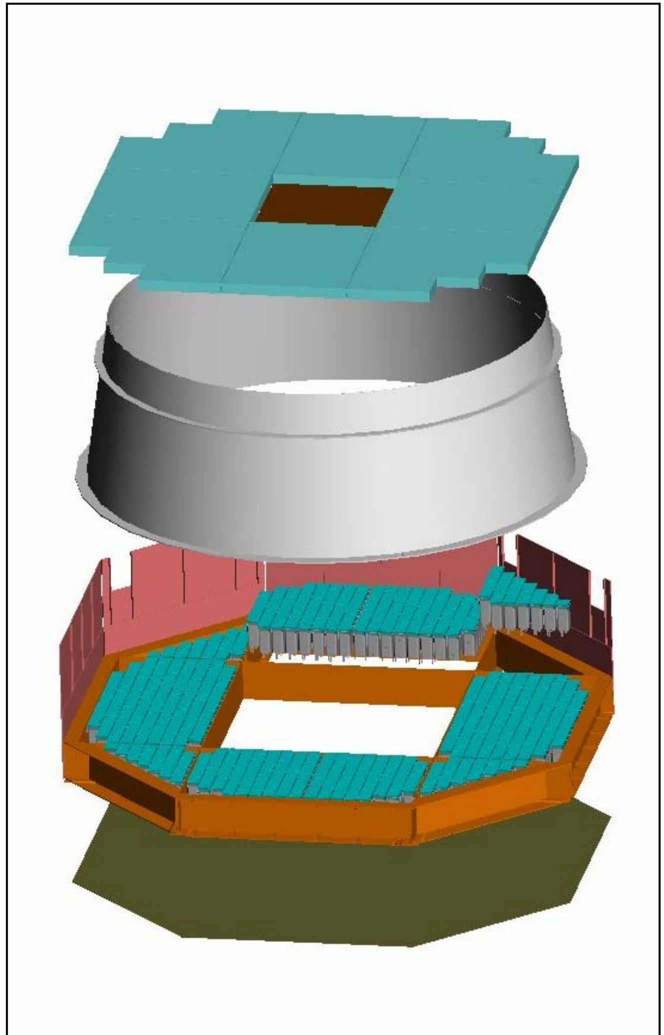
Reflector

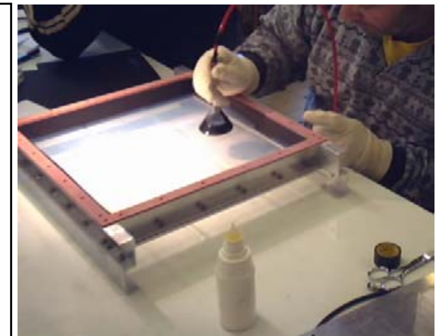
- Reduce photon losses
- Multilayer Structure deposited on a Carbon Fiber Reinforced Composite (CFRC) Substrate

Photon Detection

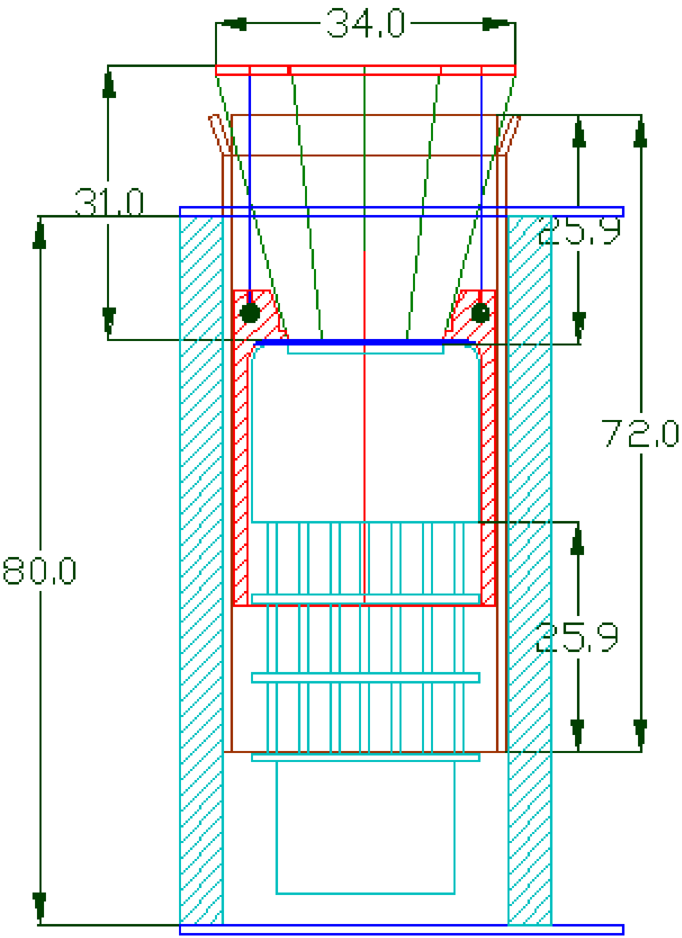
~ 700 photomultipliers (Hamamatsu 7600-00-M16)
- 4×4 mm^2 effective area/pixel
- Gain ~ 10^6 @ 800 V
- Quantum Efficiency ≈ 20 % in the range 250-600 nm

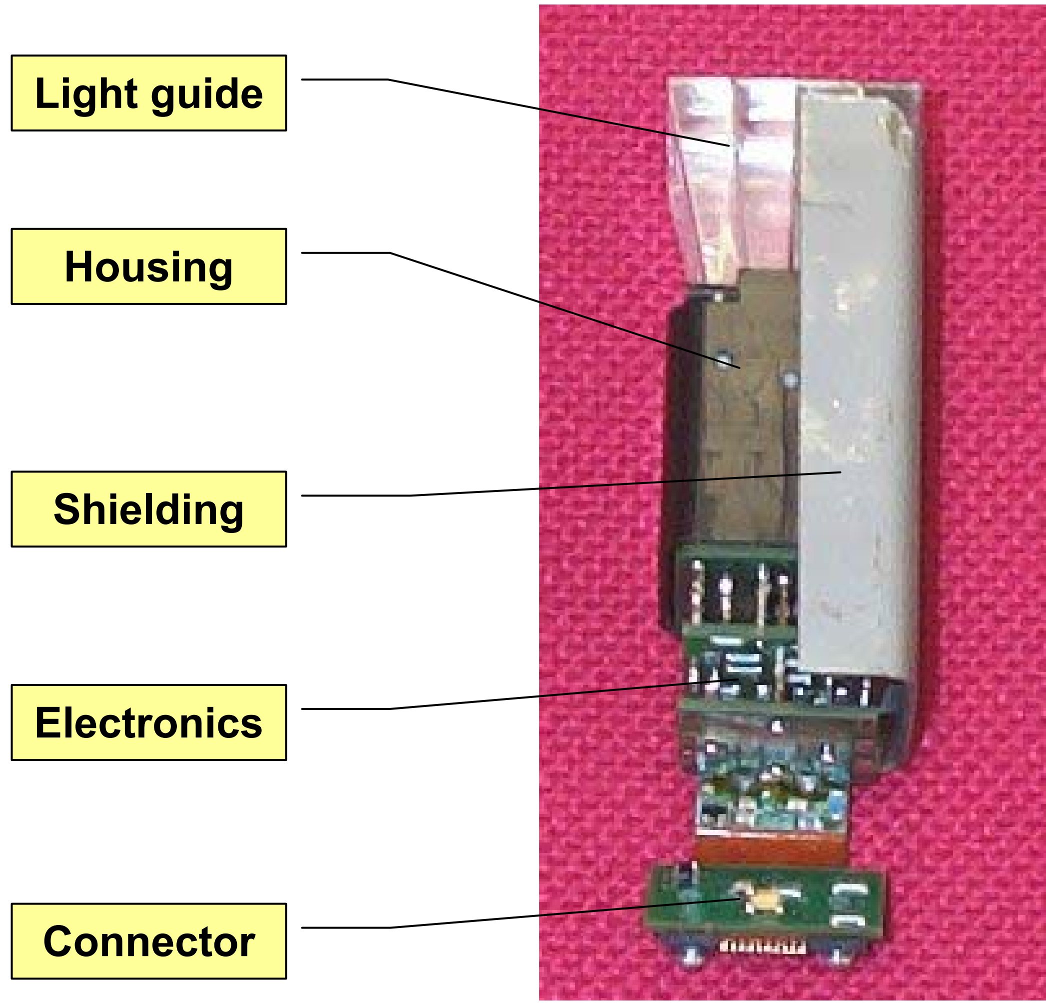
➔ B Field ⊕ 50 % Effective area
→ Shielding
→ Light guides



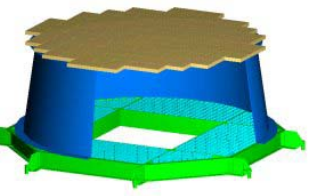


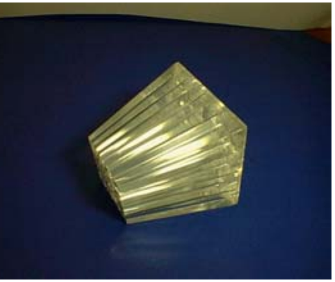
RICH Description: (2/2)





RICH Activities (1/4)





- RICH Assembly

→ Start the RICH Assembly in 2003

Current Status	Shrort term tasks
• Clean Room (class 100000) • Definition of the assembly procedure	• Assembly equipment and special tools • Test station

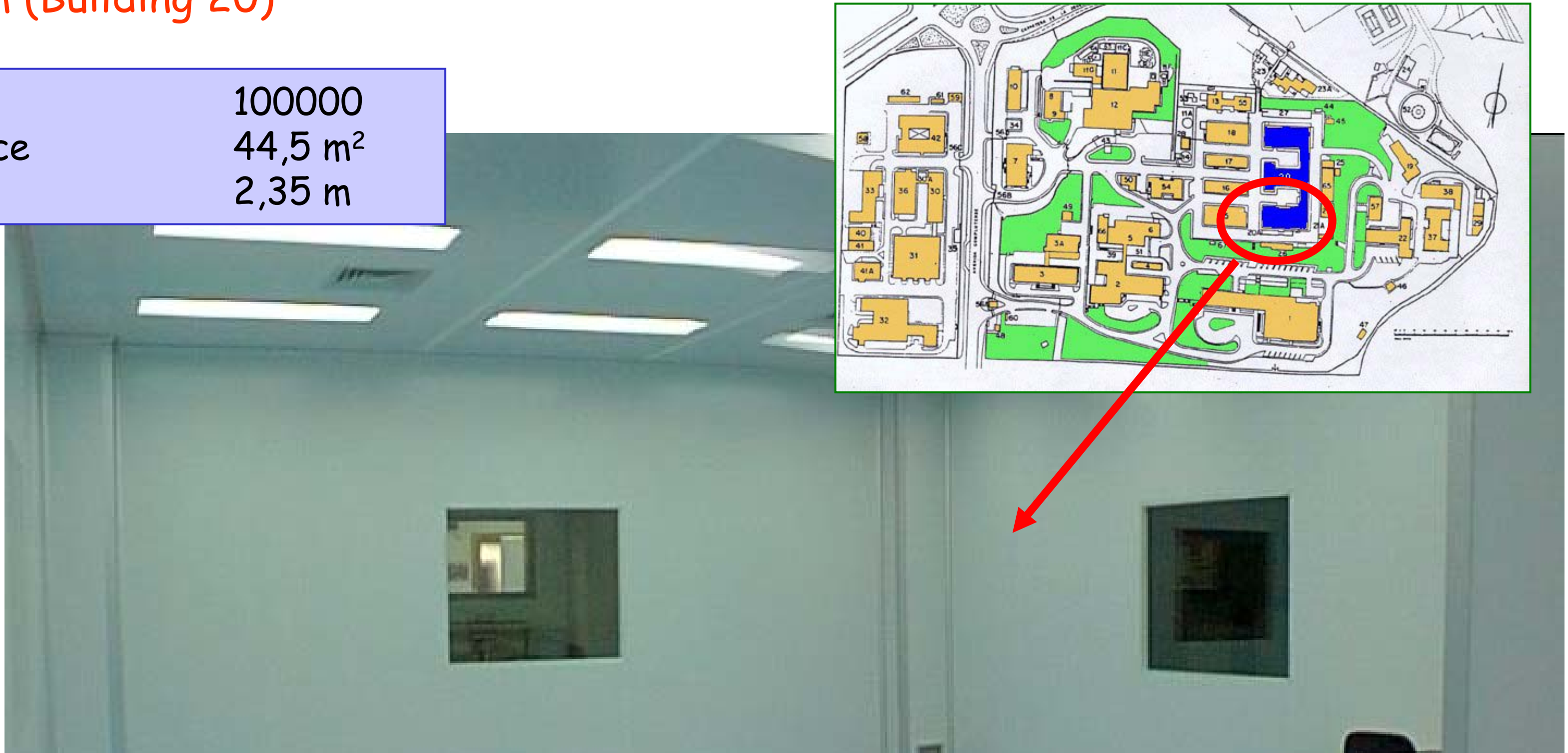
- Mechanics

Current status	Short term tasks
• Light Guide design • Optical characterisation of material • LG Fixation system • Production Protocol and quality control • Qualification test	• Flight LG Units Production (700 units)

Responsible: C. Díaz, J. Berdugo

Clean room (Building 20)

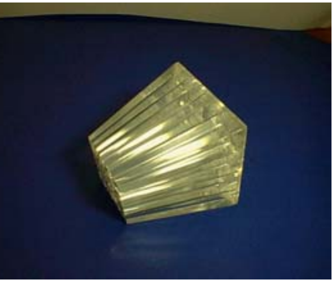
- Class 100000
- Surface 44,5 m^2
- High 2,35 m



Clean Room Equipment for RICH Assembly

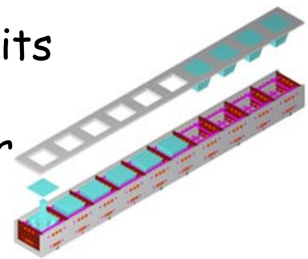
- Oven for potting and adhesive polymerisation
- Reference table (1,0 x 0,5 m^2)
- Movable crane (1 T)
- Jigs for grid integration (triangular and rectangular)
- Jig for Structure – grid integration
- Jig for Structure – reflector integration
- Jig for RICH structure movement and support (tilting capability)

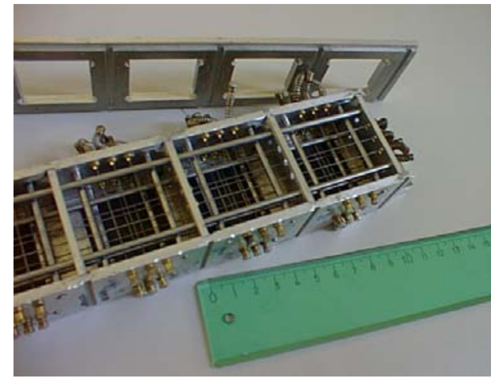
Light guides



- Materials:
  - Acrylic Plastic free of UV absorbing additive (16 units + top plate)
  - Glue: EPO-TEK 301-2

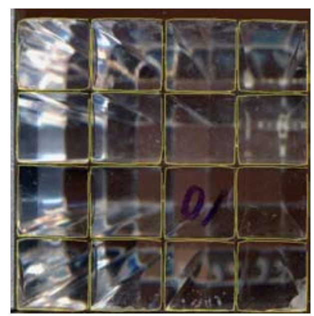
- Assembly:
  - prototype tool for 10 units
  - glue degassing
  - automatic glue dispenser
  - curing at 80° C
  - mechanical finishing

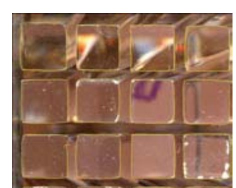


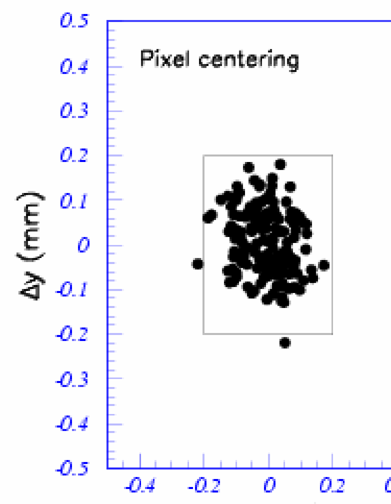


- Dimensional test
  - ✓ Overall dimension
    30,8 x 30,8 mm
  - ✓ Spacing inside tolerances
    0,2 mm

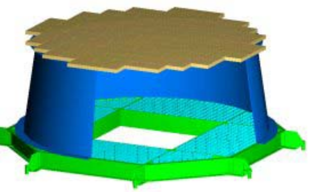
Top view

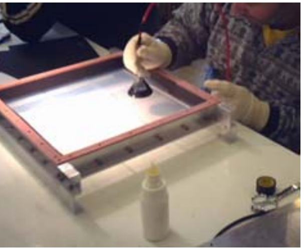






RICH Activities (2/4)



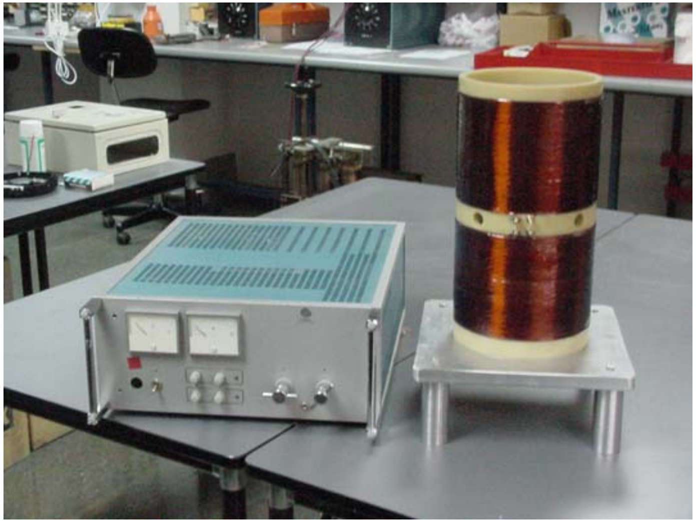


- Components

Current Status	Short term tasks
• Acquisition of 225 PMT's • PMT charact. protocol • PMT charact. in magnetic field • Aerogel optical characterisation	• Characterisation and sorting of PMT's • Aerogel aging • Final Aerogel Acquisition

Responsible: C. Mañ

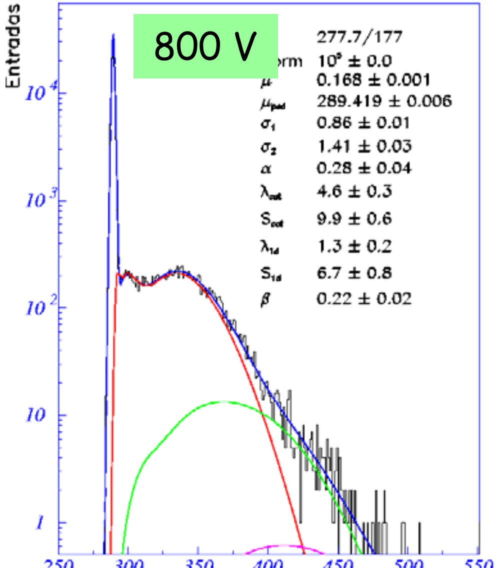
PMT characterisation

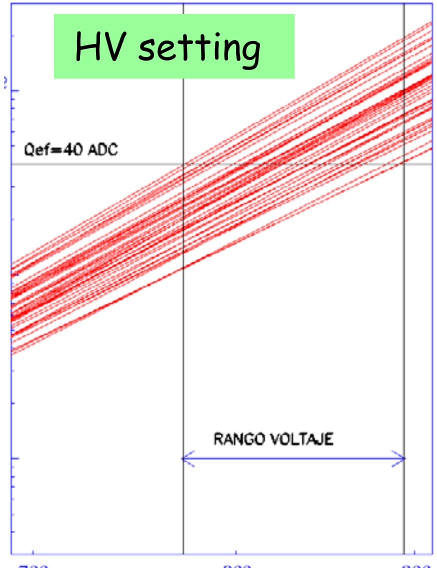


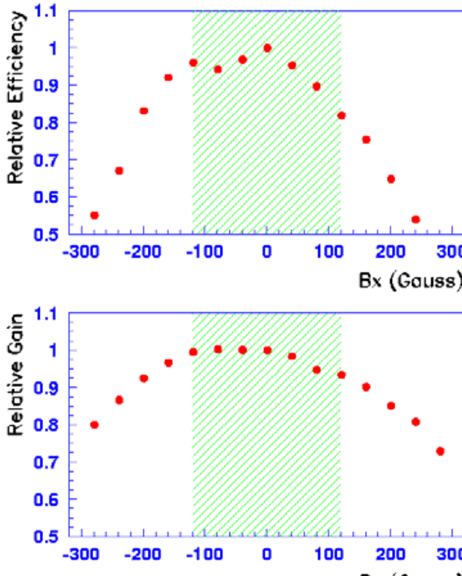
Single photon response

Uniformity

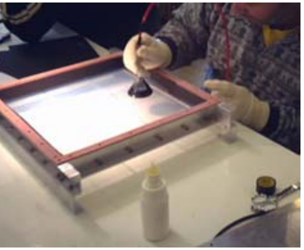
B Field effect







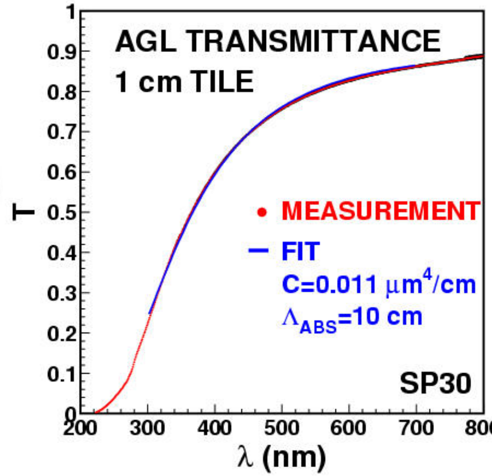
Aerogel characterisation



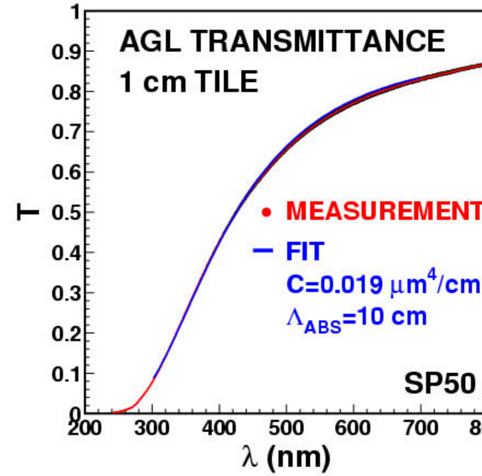
Transmittance of Matsushita SP30 and SP50 silica aerogels

UV-VIS-IR Spectrometer
at
Materials Lab. @ CIEMAT

SP30



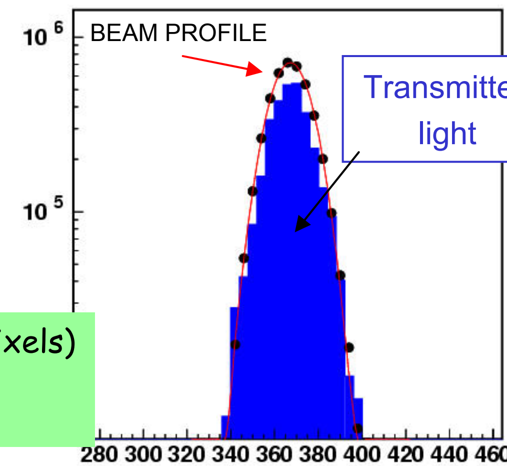
SP50



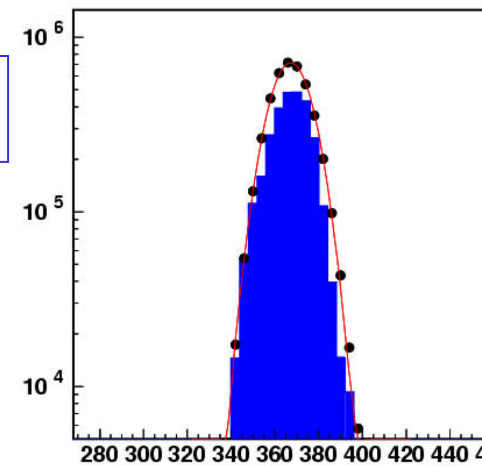
Light (λ = 633 nm) dispersion at 500 mm

RadEye1 Sensor (1024x512 pixels)
at
Optical Lab. @ IFCA

SP30



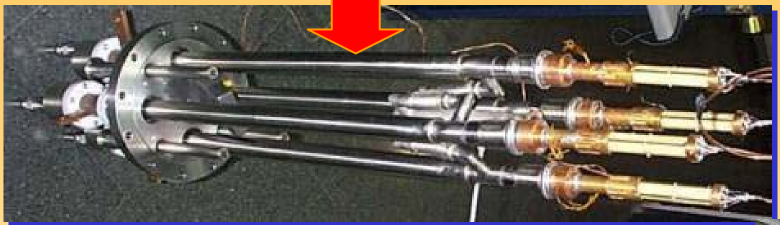
SP50



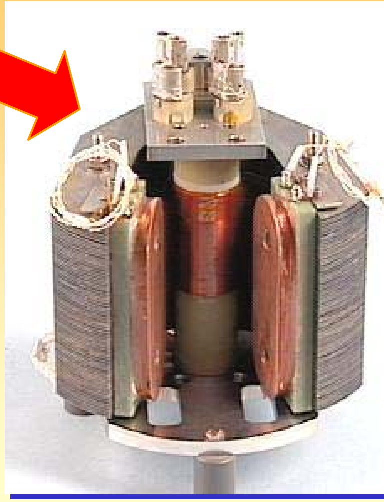
Applied Superconductivity Group - Status Report till 2002

Design and fabrication of LHC prototype superconducting magnets:
- Tuning quadrupole (1989-92)
- Corrector sextupole (1992-95)
- Superferric octupole (1993-94)
- Two trim quadrupoles (1997-00)

600 A HTS current leads for LHC correctors (1998-00)



Magnet tests (1994-00):
- training tests
- special purpose tests



HTS fault current limiters (1998-01)

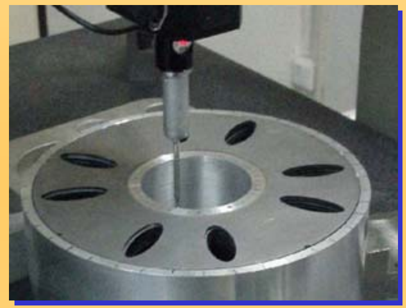
Design, fabrication and tests of a 1 MJ SMES (1994-96)

Applied Superconductivity Group – Status Report 2002

Report on the design and calculation of the TESLA500 magnets and their accessories, including a cost estimate for the prototypes and the series production.

Lab tests:

- LHC combined magnet MSCBX
- Superconducting switch from ANTEC
- Shrinking cylinder for magnets
- MQTL prototypes at CERN test hall



Dimensional metrology of superconducting magnets based on digital image processing

CIEMAT

Department of Fusion and Particle Physics

Electronics and Automation Laboratory

Activities:

- Development of electronics within R&D projects, mainly in collaboration with other projects of the Department
- R&D line on radiation detectors
- General support and consulting services for CIEMAT projects under demand

Personnel & Budget

Total number of researchers & engineers: 14

• Aguayo de Hoyos, Pablo	M.S. in Computer Engineering
•Alberdi Primicia, Javier	M.S. in Computer Engineering, M.S. in Mech. Engineering
•Barcala Riveira, José Miguel	M.S. in Physics
•de Burgos García, Eduardo	M.S. in Physics M.S. in Mechanical Engineering
•Fernández Bedoya, Cristina	M.S. in Electronic Engineering
•Marín Muñoz, Jesús	M.S. in Physics
•Martínez Botella, Gustavo	M.S. in Electronic Engineering
•Molinero Vela, Antonio	M.S. in Physics
•Oller González, Juan Carlos	M.S. in Physics
•de Pablos Hernández, José L.	M.S. in Physics
•Pérez Morales, José Manuel	Ph.D. in Physics
•Vela Morales, Óscar	M.S. in Physics
•Willmott Zappacosta, Carlos	Ph.D. in Physics
•Yuste de Santos, Ceferino	M.S. in Physics

Technicians: 15

Administrative Staff: 3

Annual Budget: 700,000 € (including direct, indirect costs and staff)

Personnel & Budget

Participation in projects during 2001

	AMS: RICH	CMS: Alignment	CMS: Readout	Digit. TJ-II	Febex	Suitcase	Low background eq.	Informative panel	SIMU2	Univ. Michigan	VRIMOR	Users support
Aguayo de Hoyos, Pablo	x		x									
Alberdi Primicia, Javier		x	x	x		R		x				x
Barcala Riveira, José Miguel					R	x		x				x
Burgos García, Eduardo de							R	R	R		x	
Fernández Bedoya, Cristina	x		x									
Marín Muñoz, Jesús	R		x									
Martínez Botella, Gustavo	x											
Molinero Vela, Antonio		R				x		x				x
Oller González, Juan Carlos		x	x	x								x
Pablos Hernández, José Luis de				R								x
Pérez Morales, José Manuel							x			R	R	
Vela Morales, Oscar							x		x		x	
Willmott Zappacosta, Carlos	x		R									
Yuste de Santos, Ceferino						x		x				R

RECURSOS HUMANOS

PROYECTO I+D	Investigadores e Ingenieros			Técnicos			Apoyo Administrativo	Becarios	Tot
	Funcionarios	Laborales Fijos	Contratados	Funcionarios	Laborales Fijos	Contratados			
Lab. Nacional de Fusión	11	21	19	4	11	20	5	2	93
Materiales para Fusión	1	7		1	1		1		11
Física Exp. Altas Energías	5	7	2		5	4	1	3	27
Astrofísica de Partículas	2	2	5		1			4	14
Superconduct. Aplicada	1		2						3
Lab. General de Elect. y Autom.	4	5	3	1	13		1		27
Metrología de Rad. Ionizantes	4	4	1		3		1		12
TOTAL	28	46	33	6	34	24	9	9	18