Physics
Department

Detector Technology group

Detector Technologies Group PH-DT

2011

This report gives a summary of the mandate, structure and activities of the group during the year 2011.

ANNUAL REPORT

7 May 2012

Annual Report 2011 Detector Technologies Group PH-DT

Mandate

The mandate of the PH-DT group comprises development, construction, operation and maintenance of particle detectors for the experiments at CERN. The group clusters common services and infrastructure, which are available to all experiments at CERN, e.g. gas system support, thin film lab, silicon facility with bond lab, irradiation facilities, magnet operations support, B-field mapping, instrumentation and controls.

Structure

The group is organized in 5 sections (see also the figure on the following page):

- DT/PO Project Office
- DT/DI Detector Infrastructure
- DT/TP Technology and Physics
- DT/EM1 Engineering and Mechanics 1
- DT/EM2 Engineering and Mechanics 2

The group counts currently just above 70 active staff, a number which is not expected to decrease further. Two staff members are on leave of absence at the ITER project. The number of fellows and students decreased from 20 (2011) to currently 12, caused by the end of the White Paper R&D programme and the Marie-Curie network MC-PAD.

Activities

Most of the group's activities are carried out by teams composed of physicists, engineers and technicians from several sections. It is therefore mainly the projects and services which define the working relations within the group.

In 2011 the group's activities were concentrated in five areas:

1. Completion, consolidation, maintenance and operation of the ongoing projects (LHC and other).
2. New detector projects: participation in new developments (LHC upgrade, e.g. ATLAS IBL, CMS tracker, non-LHC experiments like NA62);
3. Detector infrastructure and other services, incl. 'on-call' services, detector cooling, irradiations etc.
4. Detector R&D: participation to some R&D activities with longer term time horizon in a few strategic fields.

Allocation of resources

While the structure and mandate of the group were identical to the previous year, the natural move of resources from LHC activities (now at 40%; this includes projects (25%) and services to LHC experiments (15%)) to other areas. The fraction of the non-LHC experiments (CLOUD, Aegis, NA62, and CAST) increased to about 20%. Services to non-LHC experiments and R&D represent about 20% of our activities. The longer term R&D part is below 10% and is to a large extent carried by fellows. About 10% of the group's resources are needed for general service tasks (workshop supervision, safety and management).

The following diagram lists the DT staff members, fellows and doctoral students which were active during the year 2011. Those who retired in the meantime, or left the group for other reasons, are marked by a star.

PH-DT-PO	PH-DT-DI	PH-DT-TP	PH-DT-EM1	PH-DT-EM2
BAULT, Christophe	BERGSMA, Felix	DAVENPORT, Martyn	ANSTETT, Didier	BENDOTTI, Jerome
CATINACCIO, Andrea	BLANC, Pascal	GYS, Thierry	BOUVIER, Philippe	BODE, Alain
GARGIULO, Corrado	BOURGEOIS, Nicolas	HAHN, Ferdinand	CANTIN, Bernard	BRUNEL, Bernard
DAVID, Eric	BRAEM, Andre *	HONMA, Alan	DENARIE, Charles-Henri	CHARRA, Patrick
GODLEWSKI, Jan	CAPEANS GARRIDO, Mar	JORAM, Christian	DUMPS, Raphael	DANIELSSON, Hans
HATCH, Mark	CARRIE, Patrick	KLEMPT, Wolfgang	FRAISSARD, Daniel *	DIXON, Neil
JAMET, Olivier	D'AURIA, Andrea	MARTINENGO, Paolo	IJZERMANS, Pieter	FOLLEY, Adrian (detached to EN)
LENOIR, Philippe	DAVID, Claude	MOLL, Michael	KOTTELAT, Luc	GARNIER, François
PETAGNA, Paolo	DE MENEZES, Louis-Philippe	ROPELEWSKI, Leszek	KRISTIC, Robert	GIUDICI, Pierre-Ange
TROPEA, Paola	DERONT, Laurent	SCHMIDT, Burkhard	LESENECHAL, Yannick	GONCALVES, Antonio
WERTELAERS, Piet	FORTIN, Richard	TAUREG, Hans *	LOOS, Robert	NOEL, Jerome
	GLASER, Maurice		PERINI, Diego *	ONNELA, Antti
	GUIDA, Roberto		PIEDIGROSSI, Didier	PEREZ GOMEZ, Francisco
	HAIDER, Stefan		VAN BEELEN, Jacob	
	MANOLESCU, Florentina			
	MAIRE, Gilles			
	MCGILL, Ian			
	MERLET, Frederic			
	OLESEN, Gert			
	PAVIS, Steven			
	PONS, Xavier			
	RAVAT, Sylvain			
	SCHNEIDER, Thomas			
	VAN STENIS, Miranda			
	WASEM, Albin			

FELLOWS, DOCT. STUDENTS, TECH. STUDENTS, PROJ. ASSOCIATE
BELTRAME, Paolo *; CASTILLO GARCIA, Lucia * ; DAGUIN, Jerome ; DOLENC, Irena; DROZD, Adam ; GABRYSCH, Markus ; HELLER, Matthieu ;LA ROSA, Alessandro* ; MANDELLI, Beatrice; MAPELLI, Alessandro ; MARTOIU, Victor ; MARTOS, Vasileios* ; MAURISSET, Aurelie *; MOLNAR, Levente * ; NUIRY Francois Xavier, OSTREGA Maciej; PACIFICO, Nicola*; RUZ ARMENDARIZ, Jaime * ; SCHINDLER, Heinrich *; SERGI, Antonino ; VAFEIADIS, Theodoros ; VILLA, Marco *; VEENHOF, Rob; VERLAAT, Bart; ZWALINSKI, Lukasz.

The Detector Projects

Aegis

A large fraction of the coordination efforts went into the preparation of the experimental area infrastructure as this was not occupied by any experiment before. We successfully prepared the electrical and computer networks, gas and water distribution systems, ODH installation (for cryogenic safety requirements), etc. Combating the extreme shortage of space, we had to construct a platform for the electronics that literally hangs over the zone in order to provide the necessary rack space.

Aegis in its final configuration will consist of four major parts:

- an antiproton catching region with a 5 Tesla magnet
- a positron source with accumulation and cooling facilities
- a positron/antiproton recombination region in a 1 Tesla magnet
- a deflectometer with which the gravitational flight path of the cold anti-Hydrogen atoms can be determined.

In 2011, the 5T cryostat and part of the positron source were constructed. For the former, several components ordered in industry had substantial delays and were faulty at delivery. The repair work took many weeks and involved welding experts from the CERN central workshop. We were finally able to successfully validate all vacuum components and continue with the assembly procedure. Also here, many mechanical challenges had to be overcome due to extremely demanding welding and production tolerances. In December we transported the ¾ assembled experiment into the AD hall onto its designated beam position (see picture). After that, the central part of the experiment, the electro-magnetic Penning trap (made by INFN Genova), were all successfully inserted, aligned and cabled-up.

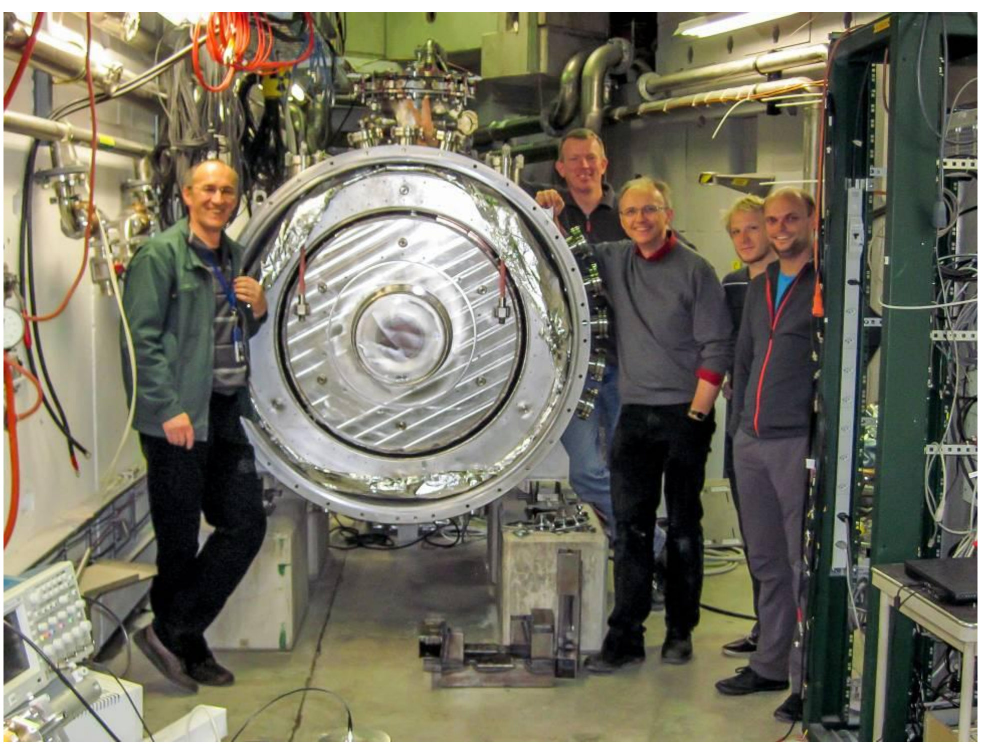


Photo*: The Aegis experiment in the AD hall.*

The first cool down of the experiment, with subsequent magnet tests, is foreseen for end March 2012.

The antiproton beam time, where we can study all intricate details of this first part of the experiment, will commence end April 2012.

ALICE

In 2011 the DT group provided technical support to the ALICE experiment in integration, installation, maintenance and consolidation of the ALICE detector and infrastructure.
Throughout the year support was given to the standard maintenance for the HMPID and TPC detectors, and the L3 magnet doors. In addition we provided access to the different subsystems on the min and main space frames, and coordinated the transport service actitivity at Point 2. We also contributed to the upgrade effort of the experiment, (the DCAL, VHMPID and ITS projects).
The group prepared and coordinated the installation of three additional TRD modules and of two EMCAL modules during the Xmas break.

***Photo**: Installation of TRD module*

Data taking in 2011 was strongly affected by the machine induced background.
This required an intervention of the group to increase shielding on both sides of the experiment.
The group extended the existing shielding wall on the RB26 side and designed, produced and installed an anti-seismic frame to hold this extension. On the RB24 side a delicate intervention of shielding around the beam pipe was also carried out.

***Photo:** Installation of one EMCAL super-module*

The group proposed, designed and implemented an intervention on the Silicon Pixel Detector(SPD).The functionality was highly compromised by a degradation of the cooling system performances, this due to the obstruction of filters in the circuit that were not accessible without removing the TPC. A long test campaign in the laboratory, reproducing the circuit layout and the development of a procedure, before the intervention on the

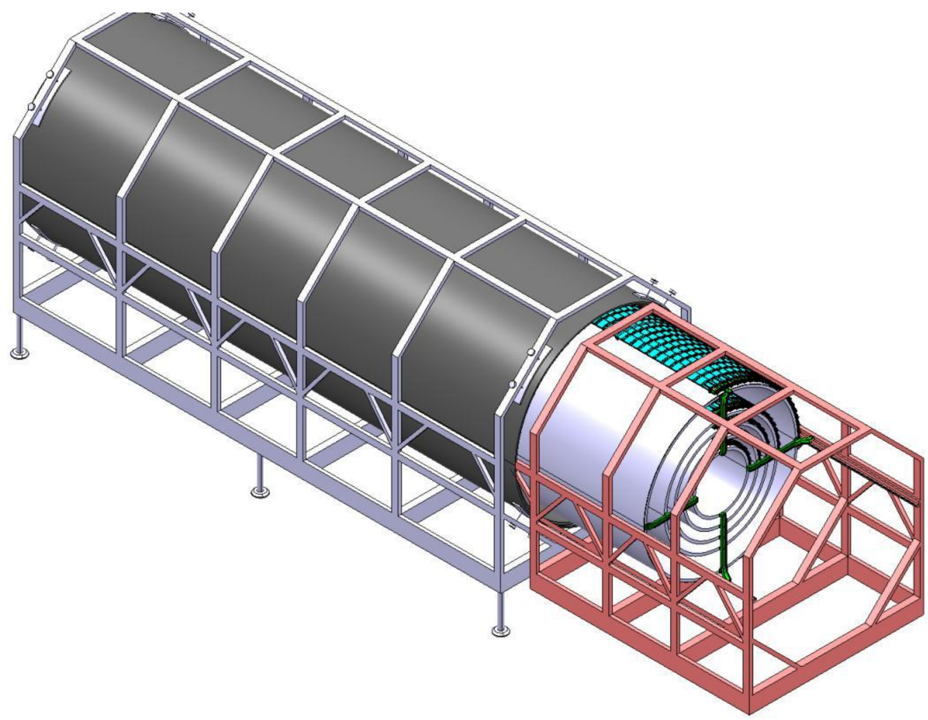
Detector, were the fundamental ingredients for the success of this intervention. Three filters were drilled at a distance of about 5m from the closest point of access using a set of dedicated tools designed and built by the group. Thanks to this intervention the SPD acceptance, which dropped below 70% in 2011, is now fully recovered (>98%).
The group was strongly involved in the upgrade studies for the experiment, from the DCAL and VHMPID projects to the ITS upgrade, with responsibilities in the technical proposals, design and testing.
For the silicon tracker upgrade (ITS) our group actively participated and contributed to the layout and structural design, to the first prototyping and to the integration and interfaces verification. This work was instrumental to the preparation of a technical proposal described in the Critical Design Review (CDR) issued at the end of the year.

ATLAS

Tracker upgrade phase 2

The section PO continues to contribute to the Atlas Tracker Upgrade phase II project in its main role of coordination for the overall engineering activities of the collaboration. The specific tasks covered in the section this year concerned the design of the global tracker system with its support, the definition of the surface assembly sequence and the installation in the pit, the integration and control of the envelopes.

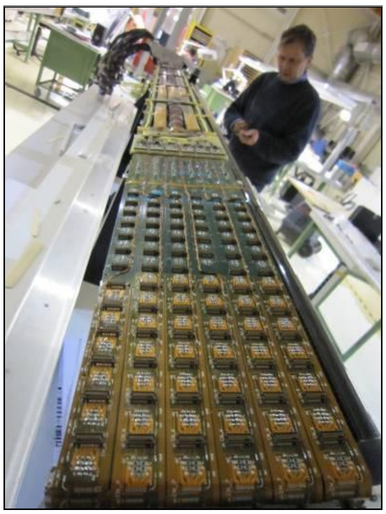
The section has also actively contributed to the engineering assessment of different layouts being submitted, the definition of commissioning, access and repair scenarios and of the tracker segmentation and the potential staging scenarios. The global cost estimate for the mechanics has been submitted to the steering committee and numerous chapters of the Letter of Intent are in preparation for the 2012 proposal to the founding agencies.



3D CAD model image*: Surface assembly: insertion of the Barrel Strips into the tracker Outer Cylinder*

Pixel nSQP project

The ATLAS Pixel new Services Quarter Panels (nSQP) project was launched in October 2010. The project consists of reproducing a new set of on-detector services, with few key changes, that will add long-term reliability to the operation of the ATLAS Pixel detector. The current on-detector optoboards will be replaced by a newly developed electrical readout, and new optoboards will be located at the ID End-Plate, facilitating their servicing. In addition to restoring the full functionality of the Pixel system, the services of the existing Pixel Layer-1 will be modified to cope with 160 Mb/s data transmission, needed for the higher luminosity LHC. The nSQP will also host a new Diamond Beam Monitor system, based on pCVD diamond sensors, adding the capability of bunch by bunch luminosity and beam spot monitor.



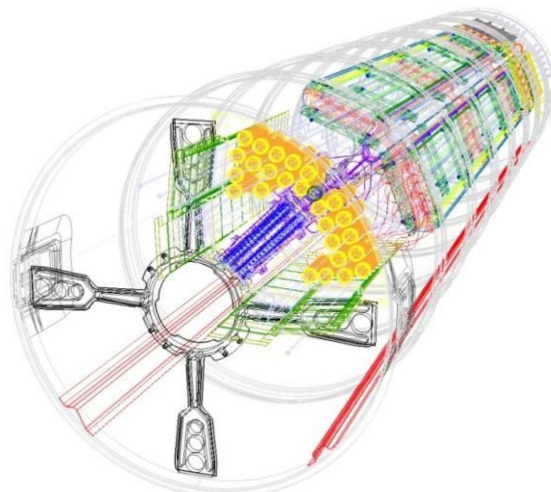


Photo Left: *Prototype nSQP built at CERN (September 2011).* ***Right 3D model image****: One nSQP fully integrated in the supporting structure.*

This year was dedicated to the set up of assembly procedures, a strict QA plan, and to build a full nSQP prototype. A successful production readiness review led to the start up of the mass production. A full set of new services have been manufactured and nSQPs are currently being assembled at CERN. Integration activities will start in mid 2012 and the nSQPs will be ready for assemby in the Pixel detector during the next long LHC shutdown (2013/14). Project coordination, mechanical support and quality assurance are project aspects where DT staff is involved.

Insertable B layer

The group is involved in the ATLAS IBL project; this consists of the installation of an additional pixel layer inside the current pixel detector. The IBL detector will be made of 14 staves held on 3 rings, with 32 pixel sensors on each stave. A new, smaller, beam pipe has to be inserted.

Within this project, PH/DT/PO has been involved in 3 main activities:

- Construction of a thermally active set up to study the IBL thermal behavior.
- Design and realization of a reliable structural connection to fix the IBL flex (IBL read out system) on the stave
- Participation in the IBL integration design work.

Active set up

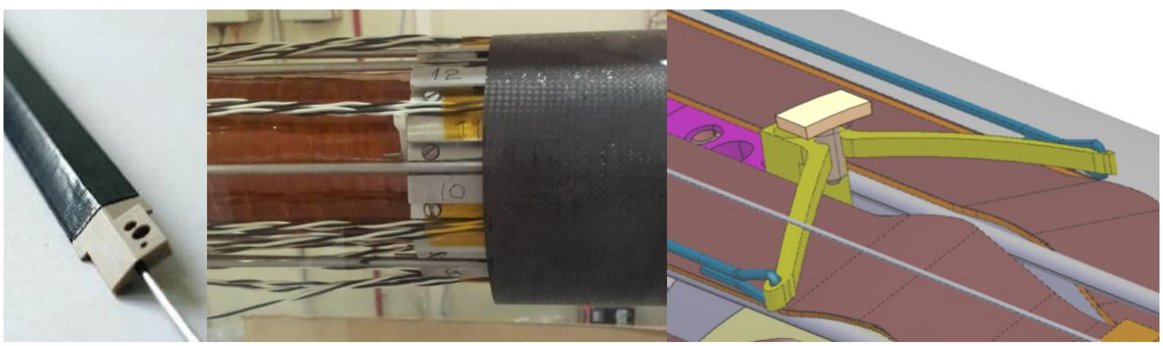
We have built a scale one thermal IBL mock up. It includes the manufacturing of 5 real staves, made of high modulus carbon fibers, thermally conductive foam and very thin titanium pipes. This mock up is integrated with a thermally active beam pipe and the IST (Inner support tube). The package is fully equipped with NTC sensors, pressure and hygrometry sensors. The environment (pressure and hygrometry) is fully controlled. The first thermal tests were performed in September and December 2011. A new read out system is currently being developed with a labview interface and tests with the new CO_2 evaporative cooling unit are planned for summer 2012.

IBL read out electronic fixation on staves

This activity focused on the development of a structural fixation between a flat and flexible electronic circuit made of Kapton, copper, aluminium, and the long and rigid carbon fiber stave. We had to deal with very different CTE and space constraints. In addition, the position of parts has to be very accurate. After many FE studies and several mechanical tests, a bonded joint has been designed. Two aluminium tools have been designed with CATIA and are now manufactured and used to glue the flex onto the stave.

IBL integration

We were asked by PH-ADO to design the PP0 region (IBL interface with services). An envelope for the flex circuits was defined, with a corrugated part allowing thermal contraction between the IBL detector and long and heavy services. A very light and accurate structure made of carbon fibres material was designed to support this interface. A system to block the IBL package in the IST after its insertion was designed with CATIA and prototyped.

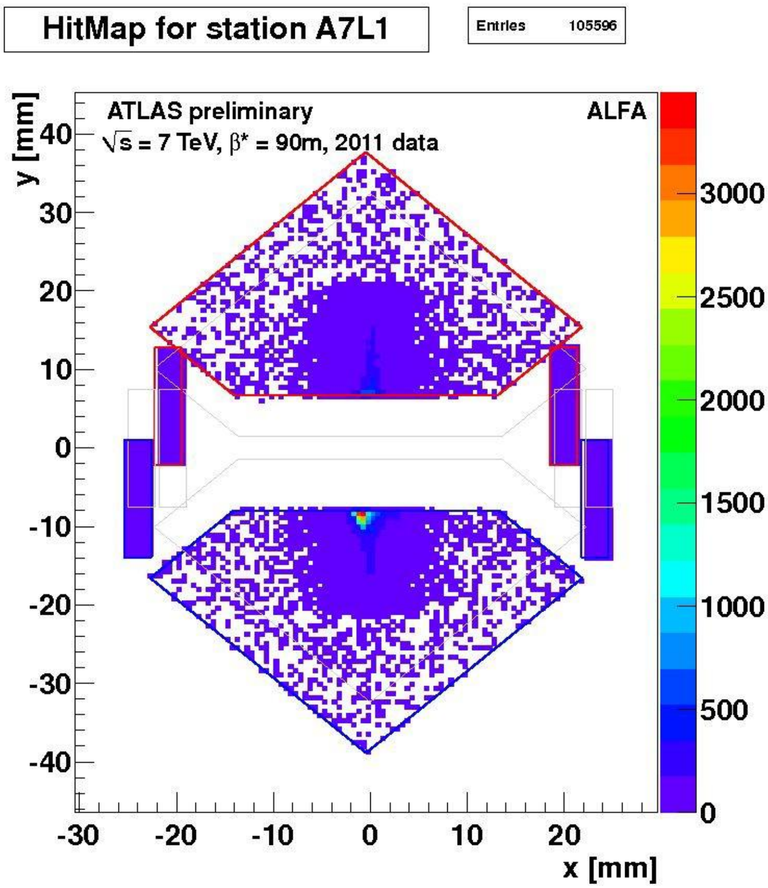


Above pictures: *Carbon fibre staves, the IBL thermal mock up assembly and the IBL integration concept.*

ALFA Roman Pots

ALFA consists of four so-called Roman-Pot Stations containing tracking detectors positioned in the LHC tunnel on both sides of the ATLAS detector, at a distance 240 m. The Roman Pots housing the scintillating fibre detectors can be moved remotely thus allowing the detectors to be positioned to within 1.5 millimetre of the LHC beam after the beam has been injected and accelerated.

Following installation during the 2012/11 shutdown, the 4 ALFA stations recorded in 2011 first data from pp collisions at 2 × 3.5 TeV energy. The full system appears to perform according to expectations. A fellow from the group made major contributions to the RP detector alignment and data analysis.



***ALFA performance plots** at β*= 90m. Track map of all particles passing the 2 ALFA fibre detectors in station A7L1 at ATLAS side A.*

The detectors are located at about 7 mm from the nominal LHC beam axis. The tracks belong to particles from beam gas interactions, protons from the beam halo and elastically scattered protons.

A new phenomenon was observed during high intensity runs, when the RP detectors are retracted 'unused' in their garage positions: the detectors heat up significantly due to power dissipated by the passing proton bunches. Apart from some regular shutdown maintenance, members of the group were involved in the comprehensive analysis of this problem: thermal cycling measurements of detector modules in the QART lab, extraction and inspection of a detector during the shutdown as well as the preparation of a RP detector with numerous additional temperature sensors. The prognosis for the 2012 data taking is positive. However, the problem needs to be followed up to prevent any possible damage of the detectors.

CAST

The group gives support to the CAST experiment in the areas of technical coordination, operation of the ^{3}He system, operation of a Micromegas (MM) detector, mechanical and electrical components of the magnet movement system, cold windows, slow controls and vacuum interlocks.

During 2011, CAST reached an important milestone by completing the data taking for the ^{3}He phase of CAST which started in 2007. The axion rest mass scan (made by scanning the density in the 3He gas-filled cold bores of the CAST magnet) surpassed the original aim and finally reached an axion rest mass 1.18eV/c2. The operation of the complex ^{3}He gas system, the monitoring of the ^{3}He metering system and the operation of one Micromegas detector (built by IRFU-Saclay) was the responsibility of a Fellow and a Doctoral Student in the group.

Daily movements of the 50t CAST experimental system, since the start-up in 2003, have taken their toll on the movement system and the magnet 13kA power cables. An urgent intervention by the DT group was required during data taking to replace a faulty wheel bearing on the movement chariot. This timely intervention enabled the ^{3}He run to keep schedule and reach completion in July 2011.

In the long shutdown of CAST a replacement of the worn 13 kA cables was planned (supervised by EN-EL & EN-MEF with assistance from PH-DT). Before this replacement took place, the DT team made a campaign of movement tests and measurements. The mechanical analyses, made together with CAST, defined a course of action to consolidate the movement system and equip CAST for running for a further 5 years, if necessary. A major intervention by the team was made to replace all wheel bearings and realign the chariot wheels with the centre of rotation. A thorough overhaul of the rest of the system was made including changing the lifting jacks and recalibrating the load pins. This prepared the movement system for a full alignment GRID measurement together with the surveyors (BE-ABP) to produce a new solar tracking reference dataset for the 2012 run. These actions should enable CAST to run the solar tracking system reliably with the necessary pointing accuracy for a number of years to come.

The group has completed and commissioned a detector test lab containing a variable energy vacuum x-ray beam line. This year vacuum and high voltage interlock systems and slow control monitoring, plus the x-ray detector chamber gas systems and mechanical supports for the vacuum line were installed by the group. This facility will be first used to make energy calibrations of CAST Micromegas detectors, as part of a DT Doctoral Student's thesis project.

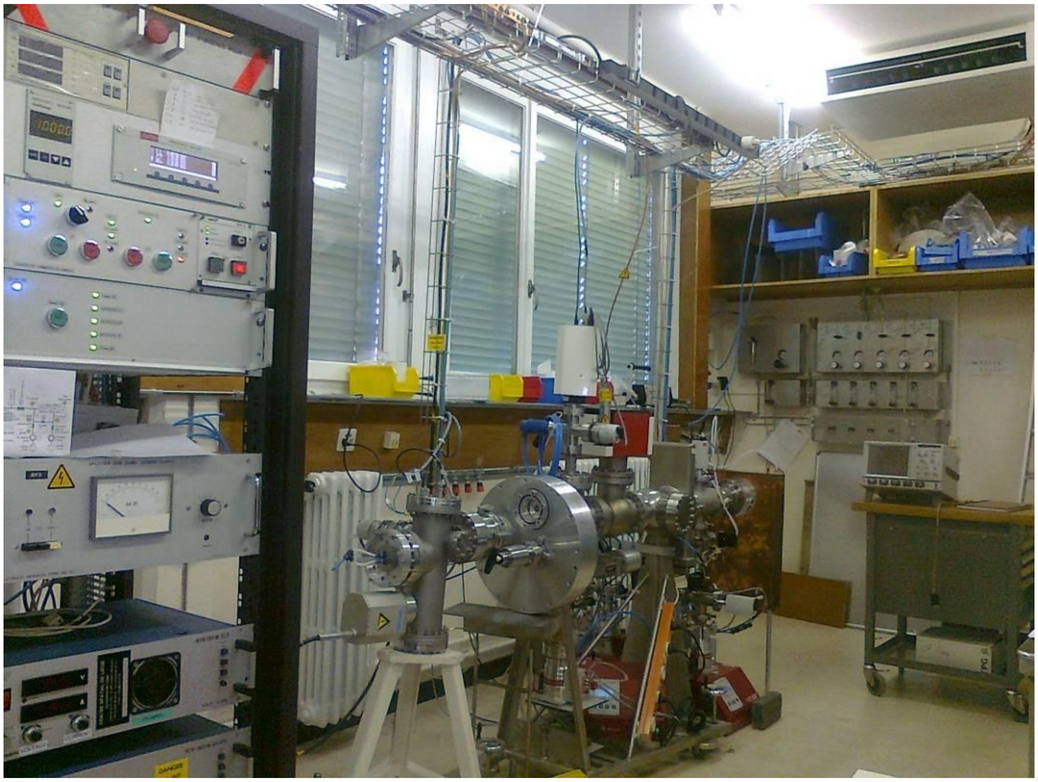


***Photo**: Detector test lab with X-ray beam line*

CLOUD

Based on the data obtained in 2010, the first major results of the CLOUD experiment were published in the Nature journal: *"Role of sulphuric acid, ammonia and galactic cosmic rays in atmospheric aerosol nucleation"*.

The two CLOUD beam runs of 2011 focused on measurements in low temperatures, to -65^{o}C, and on the influence of organic vapours in the neutral and ion-induced aerosol nucleation.

DT contributes to the experiment by an engineer acting as the Technical coordinator and GLIMOS, and a technician providing support to the experiment's construction and maintenance activities. In addition the DT gas and thin film workshops are closely involved in the development and production of CLOUD's sub-systems. The 2011 upgrades of the CLOUD facility were:

- Completion of the thermal housing and precision thermo-regulation system (to -65C).
- Cold racks (to -25C) for the sampling instruments.
- Completion of the final manhole covers and magnetic mixing fans.
- UV sabre for a) rapid aerosol growth and b) suppression of organic contaminants.
- Gas system upgrades for precision supply of organic vapours with low saturation vapour pressures.
- Commissioning of a synthetic ultrapure water system.

Photo: *View of CLOUD in the East Hall T11 zone during the June-July 2011 run to study neutral and ion-induced nucleation involving organic vapours.*

CMS

Detector cooling system operation

The PH/DT team has been involved in all activities linked to the existing CMS cooling systems:

- Operation support & coordination during the year, for both water and fluorocarbon systems: smooth operation during 2011
- YETS maintenance on all CMS parts of the circuit & coordination. Intervention of the DT team plus additional CMS technicians for several “routine” activities (filter cleaning, leak repair, Totem demineralization cartridge replacement, Tk plant sealing). In addition: investigations on high temperature problems at the Yoke level, faulty quick connectors (The plan for the replacement of all such connectors during LS1 was launched).
- Fluorocarbon consolidation for LS1. Preparatory study performed with EN/CV during YETS. Planning for intervention during LS1 is underway.
- Tracker Humidity sealing in LS1. A task force chaired by a DT engineer has been set in order to define and plan all the activities of consolidation of the humidity control and monitoring in front of the TK end-flanges during LS1. DT actively participates and will play an important role during the work execution during LS1.
- Water system consolidation by the changing of components.

Pixel Luminosity Telescope

The new design of the PLT cassette, endorsed and prototyped last year, has been finalized and built. Two cassettes, each equipped with 2 telescopes have been installed on one CASTOR Table. An ambitious plan of redesign of the present BCM carriage has been also launched in PH/DT. This aims to an improved integration of the BCM carriage with the PLT cassette providing more freedom for in-situ geometrical adjustments of the PLT alignment and the possibility of mounting 4 BCM modules per carriage.

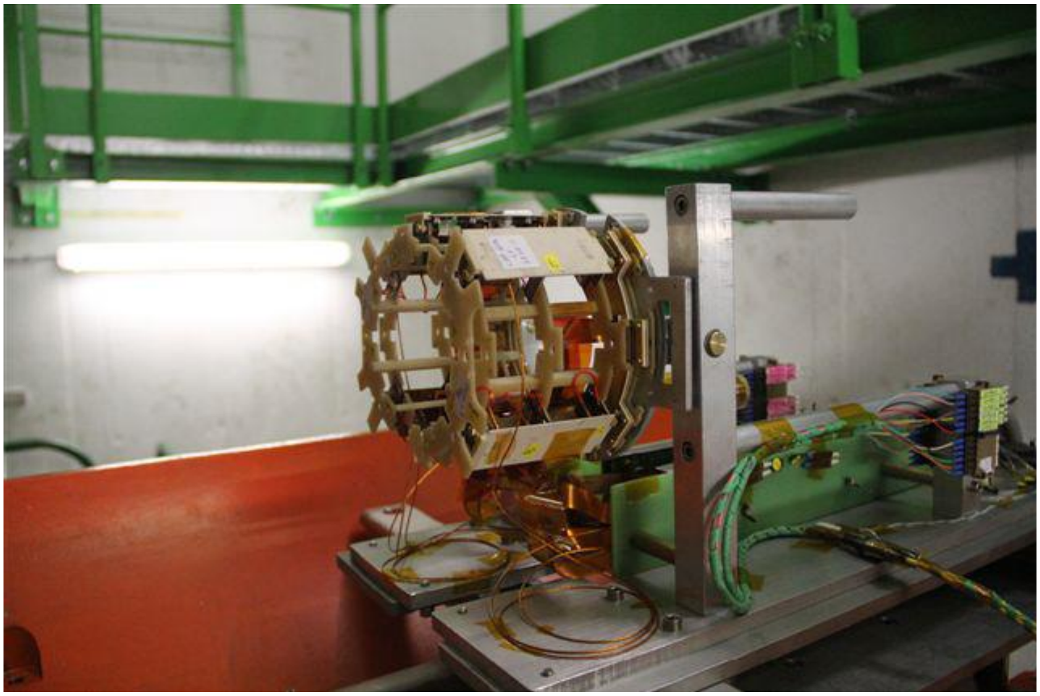


Photo: *Two PLT cassettes mounted on one Castor table in UX5*

Upgrade to CO2 cooling

PH/DT has the full responsibility of the delivery of the CMS PIX upgrade CO_2 cooling system. A mixed team of DT and CMS engineers has steadily advanced during the year on the definition of the specifications and on an integrated design of the plant and of the PIX detector cooling layout.
The design is now in its final engineering phase.
In the meantime the critical work of qualifying the existing CMS copper pipes for use with CO_2 has been launched. Tests executed in PH/DT labs have proven the compatibility of both the pipes and the soft-soldered joints with all safety guidance applicable to CO_2 piping. A full scale test to investigate the thermo-fluid performance of the existing long transfer lines has been set-up at the Cryolab CO_2 facility.

CLIC W-HCAL

The group has continued in the effort to validate Tungsten as a possible absorber material for a high granularity hadron calorimeter aiming for a compact design for a future CLIC detector. In the framework of the CALICE collaboration, the beam tests have been carried out at the SPS covering energies from 10 GeV to 300 GeV. The existing physics prototype has been extended to 38 layers of W absorber with a total absorption length 3.8Λ. As detector elements, the fine-segmented scintillator tiles (3 x 3 cm^2 in the core region) from the CALICE AHCAL prototype with an analogue readout have been used. In order to contain the showers, especially for higher energies behind the calorimeter, a tail-catcher with a total absorption length of 5.4 Λ has been positioned. During a total beam time of 4 weeks, 33 M events have been taken. The analysis of the data is ongoing, preliminary results are promising and allow the determination of resolution and shower sizes. For 2012 the prototype will be equipped with RPC based detector cassettes that feature a digital readout on a very fine segmentation of 1 x 1 cm^2. Test beams at the PS as well as the SPS are planned to measure the performance with energies from 1 GeV to 400 GeV.

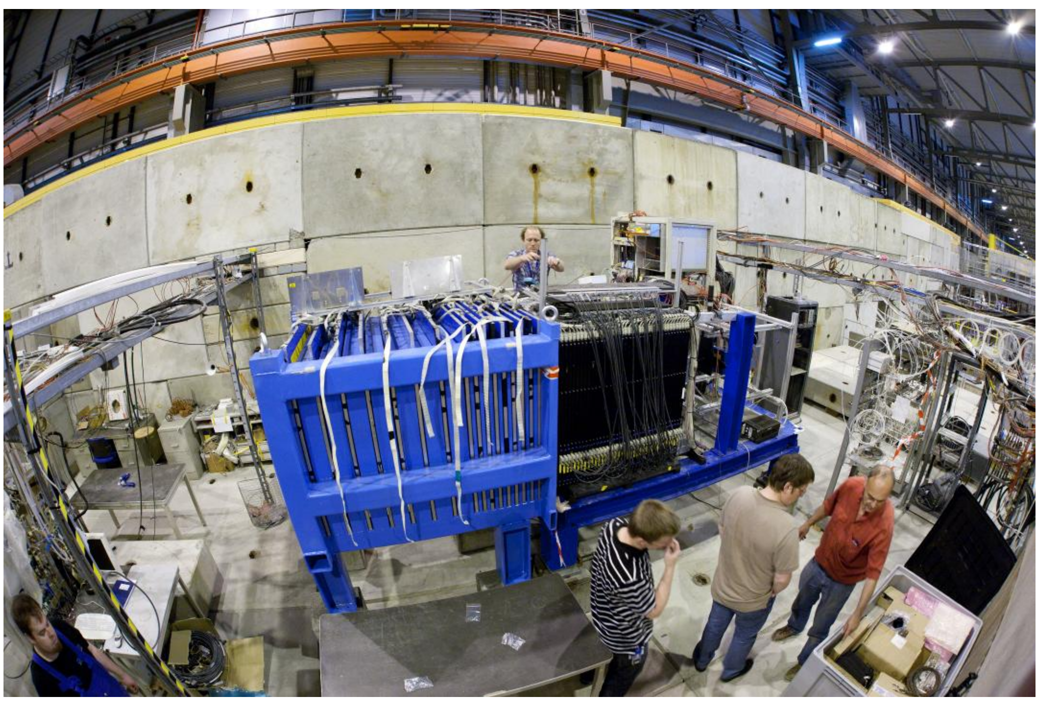
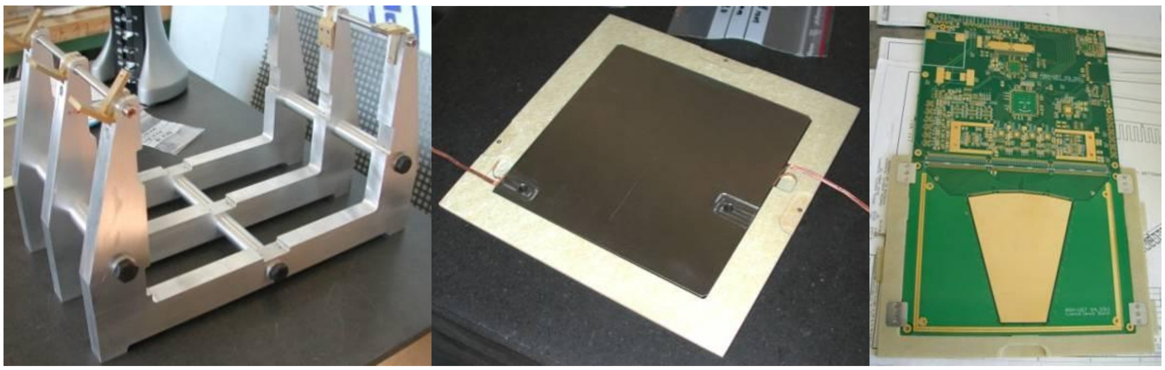


Photo:*The WHCAL prototype in the SPS test beam H8*

LCD

The PH-DT-PO section has been involved in the design and construction of the mechanical structure, and some auxiliary equipment, to be used as precise support for prototypes of a future very forward calorimeter in a test beam.
The calorimeter concept consists of 30 absorber plates of 3.5 mm thick tungsten, interspersed with silicon sensors. The requirement was to provide a flexible infrastructure that allows the testing of sensors, inside tungsten sandwich calorimeters, assembled with high accuracy. The distance between tungsten plates must be variable, 0.5, 1 or 2 mm, and an accuracy of ± 50 microns or better is mandatory. A first test setup has been designed and manufactured, tungsten plates are ordered. All the other detector aspects (services supports, hood protection, handling system and cooling systems) have also been taken into account in the design.



***Photos**: The calorimeter frame, one tungsten plate in its permaglass holder, and a sensor in its holder.*

LHCb

Detector Operation

The DT group has carried out operation and maintenance activities for various LHCb sub-systems, in particular on the VELO, RICH, Calorimeter and Muon detectors. The winter shutdown activities have been successfully completed by early February 2011 and the LHCb detector is in excellent shape for the 2012 LHC proton physics run.

During 2011 the group was involved in the assembling of the VELO replacement detector. Besides coordination tasks, metrology measurements for the detector halves were carried out by a member of the group to verify the integrity of the new mechanical supports.

The DT group has continued to carry out operation and maintenance activities of the RICH detector, in particular the repair and further optimization of the high voltage system. As responsible for the pixel hybrid photon detectors (HPDs), the group has conducted the replacement of another 40 vacuum-degraded HPDs. Half of these tubes had degraded very quickly for reasons of bad re-processing in the company.

The DT group has been deeply involved in the RICH detector performance and optimization, in particular as the LHC luminosity was being increased well beyond the original LHCb design specifications. During that period, some issues were experienced but successfully overcome. The most severe one was in the form of coronas developing between some HPD’s (operated at high voltage) and their close-by grounded magnetic shields. This was solved by changing the gas atmosphere in the HPD enclosures from nitrogen to carbon dioxide.

The LHCb-RICH detectors have been operating optimally and successfully in 2011. Particle identification performance was excellent, as are showing the numerous physics results from the LHCb collaboration.

Operation of the muon system

The group continued to participate in the operation of the Muon system. An automated procedure to recover individual HV channels which tripped was used throughout the year, thus simplifying the task for the shift-leader. The overall performance of the system has been very good during the 2011 LHC proton physics run. This is reflected by the fact that several key analyses, like the decay of a neutral B_s meson into a final state with two muons ($\mu^+ \mu^-$), constraining severely New Physics models, rely on an excellent performance of the Muon system.
The analysis of some Muon triggered events, with a single muon in the final state showed a μ^+/μ^- asymmetry for the two LHCb spectrometer magnet polarities. The effect could be pinned down to small misalignment in the Muon stations. Therefore a major effort has been made with involvement of a member of the DT group to bring the detector half stations to the optimal position for the 2012 LHC proton physics run.

LHCb Upgrade

The group participated also in the test beam activities for the VELO upgrade project and designed, manufactured and installed in H8 a new pixel tracking telescope with multiple innovative features. The design allows a full range of movements, allowing remote controlled rotation to 90^o of the device under test, translation movements allowing testing of up to 50cm modules (e.g. for scintillating fibres), and a large variation in the positioning of the telescope arms. The current resolution of the telescope is below 2µm. It has been adopted by the AIDA collaboration to serve as part of the AIDA infrastructure, in addition to the use for LHCb.

In addition, several diamond CVD prototypes were received and have been the characterized and tested, specifically with respect to the thermal performance needed for the LHCb upgrade. Dedicated supports and interfaces to the CO_2 cooling were designed, allowing very low temperature operation and tests of irradiated samples in the beam.

R&D

Within the framework of the LHCb-RICH upgrade, and in particular the TORCH project, the timing and gain performance of commercial Micro Channel Plate Photon Detectors have been investigated in the laboratory. A single-photon time resolution <40ps was measured with an efficiency of ~90% of producing a valid timing output.

NA62

Technical Coordination

Civil Engineering and New Beam Dump

A very significant achievement during the last 12 months was the completion of the new Beam Dump in February this year. The civil engineering work consisted of excavating behind the downstream end of ECN3, so that the cavern could be extended by a 10m long tunnel and a 2.8 m long beam dump, see below. A particular difficulty was the passage of the N2 supply line (unique supply for the Liquid

Krypton calorimeter) in the sector that had to be excavated. In order to prevent any damage, the civil engineering group has installed a custom made support structure to protect the pipeline while the surrounding earth was removed.

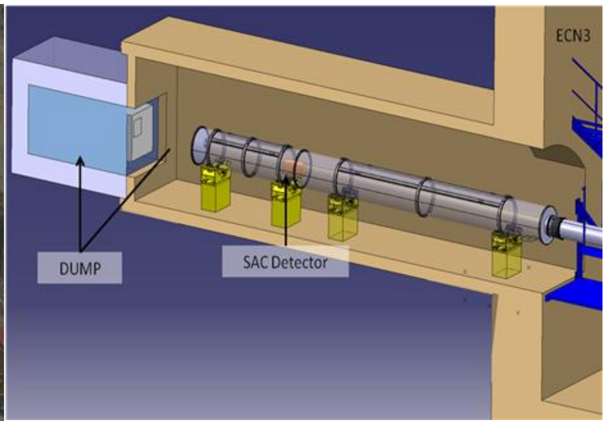



Photo: *New tunnel and beam dump from outside (left)* ***3D CAD model image****: new tunnel and beam dump (right)*

Beam Line

The design work on the future K12 beam line is completed, and the parts are in the stage of fabrication or are already available. For example, the delivery of the TAX blocks is expected for June and some specific beam tube parts are under fabrication at CERN.
The installation work has started in autumn last year, but was interrupted due to crane problems in TCC8 and due to competing work on the LHC and the injectors during the shutdown.
A critical item for the completion is the new cooling plant of the T10 target. The design work of the plant is completed and an adequate location has been found (PPX gallery towards B912). EN/CV expects to sign the installation contract end of March, and the firm should complete the installation in August 2012.

Vacuum System

The design is completed and in February 2012 the tender for the future vacuum system was sent to the firms selected in the Market Survey. It is expected that CERN can place the order in April 2012. The future contractor shall then provide and install three cryo pumps by August 2012 for the planned technical run.
A first test of a cryo pump was done by pumping on three consecutive vacuum tanks. Using an existing LAV detector prototype, it was demonstrated that the cryo pump has no negative temperature influence to the neighboring LAV detectors.

Installation Work and Schedule

During the last 12 months the collaboration and the technical staff from CERN have worked with high pressure on the preparation for the new experiment and its environment. We report here on the main achievements and problems:

Infrastructure:

The electrical installation in the surface and underground areas has been completely revised and is being consolidated at the moment. The installation work is progressing well and is expected to finish by end March. The design of a new HVAC system for TCC8 and ECN3 ,taking into account the requirements from safety protection, has made progress.

During the recent installation work we have suffered from several breakdowns of both cranes in the underground areas TCC8 and ECN3. As the cranes are quite old one can also not exclude that these problems re-occur in the forthcoming months when the cranes will be very heavily used. In the longer term, a full refurbishment of both cranes is crucial and has been requested to start right after the technical run.

***Photo**: Vacuum tanks and LAV detectors recently installed in TCC8.*

Services

The electronic racks (for the detector readout) and the connecting cable trays have been positioned and installed. The cable and fiber network (readout and slow control) have been defined and the installation is ongoing. The clock, DAQ and network fibres will be blown through their pipes in April 2012. The long distance cables for Slow Control will be installed between April and June 2012. The electronic crates for the technical run were ordered and are expected for April 2012, the detector cabling will start thereafter.

Surface Building (B918)

The surface building is still under refurbishment (electrical system, HVAC, painting), and the work progress is in line with our schedule. The equipment installation has started in the PC Farm room where standard air cooled electronic racks and network equipment have been installed. The water cooled PC farm racks have been ordered and the delivery is expected for May. We anticipate using the PC farm room, the gas area and the control room as of June 2012.

Detector Installation

The detector installation is progressing well and on time with respect to our schedule. We have successfully installed nine vacuum tank elements and five LAV detectors in TCC8 (60 m long section).

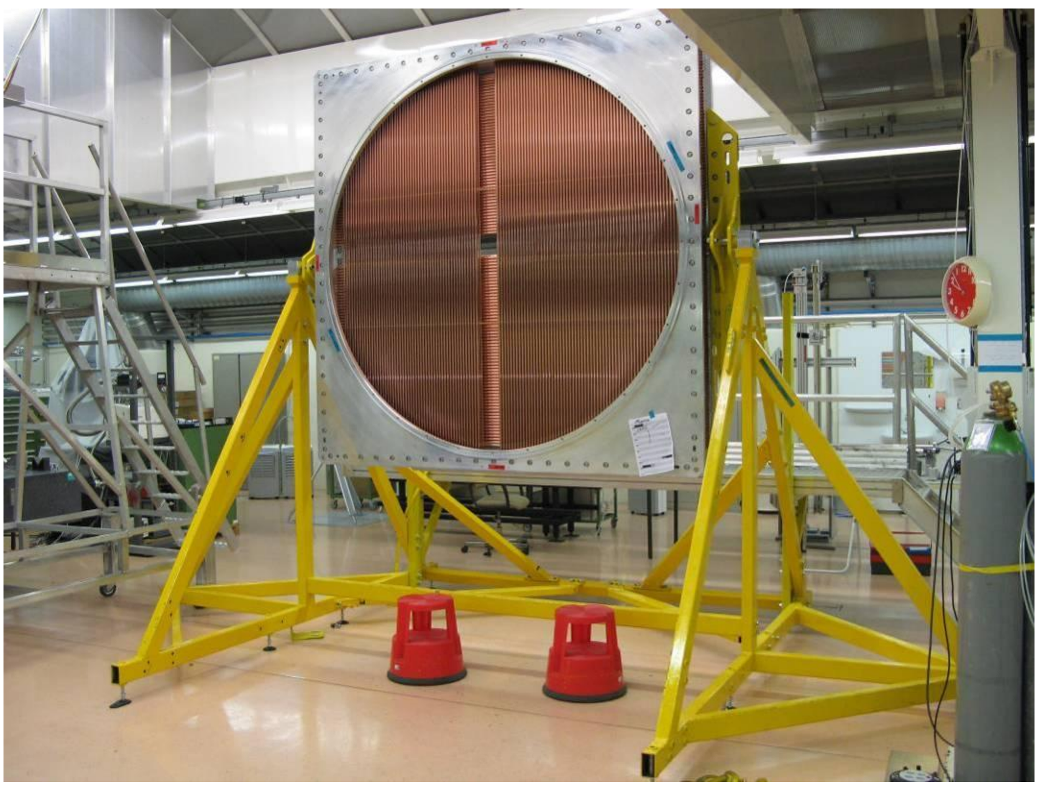
It is interesting to note that we have changed – compared to NA48- the anchoring scheme of the tank. The vacuum tanks, the LAVs, the Straw Chambers and the RICH form a solid mechanical assembly with a total length of 132m. They will be anchored in a single point in front of Straw 1, all other parts can slide (on the floor) or flex to compensate small movements caused by the vacuum forces or temperature expansions.
The NA48 CHOD has been re-conditioned and re-cabled to the new electronic rack. For the read-out we will use either the RICH or the LAV frontend. We are presently preparing the installation of the Muon Detectors planned for April and Mai.
The remaining installation program remains very tight, and is limited to a large extent by the manpower available at CERN.

Straw Tracker

The Straw Tracker is intended to measure the momentum and the direction of charged tracks originating from Kaon decays. Recent progress includes:

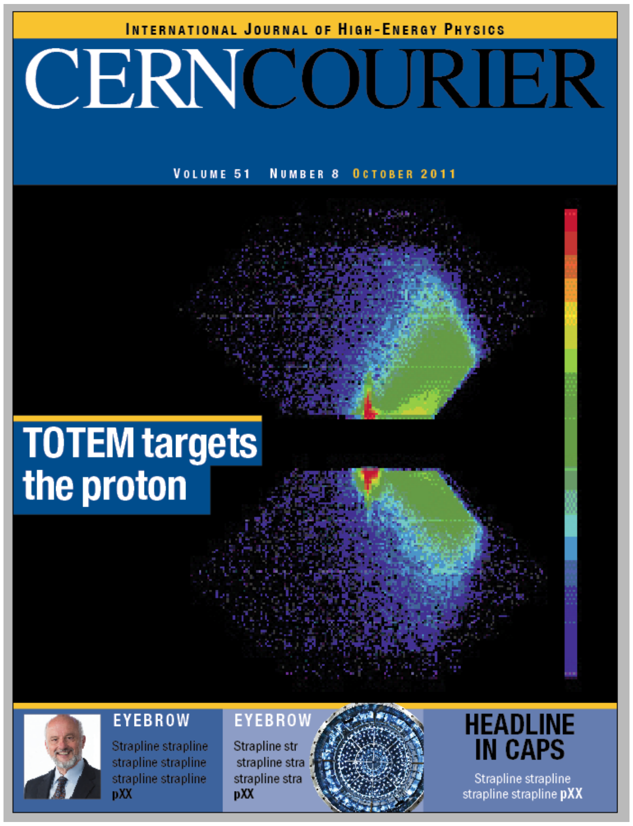
- Validation of the mechanical parts for module assembly (frames, straw spacers, manifolds, covers etc.)
- Validation of the straw installation procedure in terms of mechanics (straw position and straightness) and leak tightness
- The reception of the first five modules frames.
- Validation of the electrical connections (signal and high voltage distribution) to the straws using the so-called webs. The measured cross-talk between channels (< 3%).
- The FPGA-based TDC have been integrated on the front-end board (cover) and the first tests are successful.
- The first version of the straw readout board (SRB) is tested and working

Photo*: Completion of the straw installation after verification of straw straightness and leak tightness.*



TOTEM

After the successful installation of the second batch of 12 RP detectors at ±147 m from the CMS interaction point, the full TOTEM RP system ran nicely throughout 2012 and led to a number of physics results like the measurements of the pp elastic, inelastic and total cross-sections.



In October 2011 TOTEM RP system appears on the title page of the CERN courier

Apart from numerous interventions during technical stops and maintenance work during the shutdown, the group was involved in the preparation and installation of the so-called electrical trigger system, which links the TOTEM RP stations with the CMS trigger electronics and will allow combined data taking of CMS and TOTEM.

The production of RP spare detector did not take place due to a lack of resources on the TOTEM side to prepare and test the required components.

A special effort was required to consolidate the motor control software. Some features, in combination with unforeseen operator actions, could bring the RP system in an unsafe mode. This affects both the ATLAS ALFA and TOTEM motor controls. The controls software was largely revised and re-organized and, after verification on the test system in the common RP lab, installed on both the ALFA and TOTEM RP systems.

Services provided by the PH-DT group

Irradiation Facilities

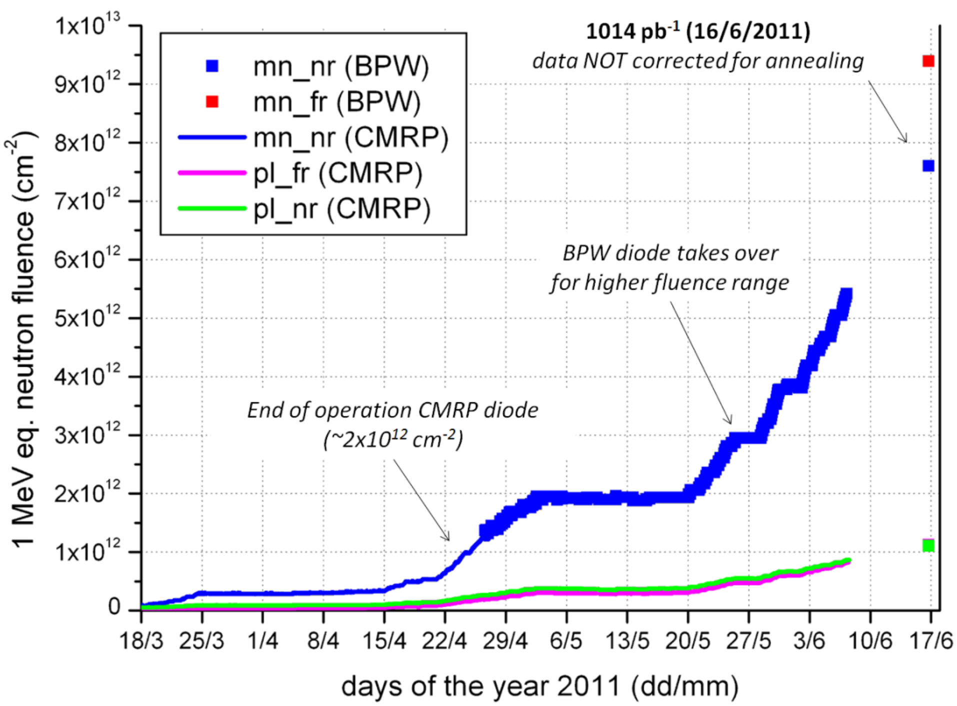
In 2011 the PS proton irradiation facilities were operated throughout 175 days. In total 651 objects were irradiated and 253 dosimeters were analyzed in order to provide the facility users with a precise and reliable particle fluence measurement for their respective individual objects under test. As in previous years the facilities served a wide international user community with the main focus on the activities related to the upgrade of the LHC. Irradiation experiments were performed for ATLAS, CMS, LHCb, RD42, RD50, RD39, LHC, RADMON and other groups and projects. The Gamma Irradiation Facility (GIF) in bldg. 190 was maintained in 2011 and intensively used by colleagues working on ATLAS MDT chambers and a group working on aging tests of RPC's and the corresponding analyses of radiation induced chemical reactions in the used gases.

With the start of the FP7 AIDA project in 2011, activities regarding the upgrade of the GIF and the EAST HALL irradiation facilities are now performed under the umbrella of AIDA. An international users group was formed that is working on user infrastructure for GIF++, a future Gamma Irradiation Facility combined with a test beam line in the SPS North AREA. The construction of the new GIF++ facility itself had however to be put on hold due to a lack of resources at CERN.

In the framework of another working group, consisting of members from CERN PH-DT, EN and DGS-RP, the planning for a new irradiation facility in the PS EAST HALL was pushed forward. Assuming that the beam line and the area that is presently used by the DIRAC experiment are available for a new irradiation facility, a preliminary layout was designed. The new facility combines a proton irradiation area with a mixed field irradiation area in a single beam line. The protons guided to this beam line are therefore efficiently used for two irradiation experiments that can run in parallel. Dedicated FLUKA calculations to understand the radiation fields and calculate the required target and shielding have been performed, confirming that this approach is both sound and feasible. In a next step more detailed FLUKA simulations are planned to study, for example, the air activation and ventilation needs. In parallel more detailed cost estimates for the facility and the infrastructure will be established.

Radiation Monitoring (RADMON)

In the framework of the PH RADMON project further integrated sensor boards and single dosimeter devices (RadFETs & p-i-n diodes) were provided to the LHC Experiments. In total, more than 90 RADMON boards and 60 sensor packages are now installed in ALICE, ATLAS, LHCb and TOTEM and working according to their specifications. ATLAS and TOTEM (see picture below) published their first radiation measurements in 2011. The continuous interest in the PH RADMON sensors has been expressed by further requests for RADMON devices for 2012 to be installed in the LHC experiments and other experimental facilities.



A 1 MeV equivalent neutron fluence in the four quarters of the TOTEM T2 Telescope located in the forward region of CMS. Data refer to the first semester 2011. Continuous lines represent data taken with CMRP p-i-n diodes (high sensitivity devices) while the square markers were taken with BPW p-i-n diodes (high dynamic-range devices). The difference between the plus (pl) and minus (mn) side of the experiment (factor ~8) is due to the neutrons produced in the CASTOR calorimeter which sits next to T2 in the minus side of CMS [F. Ravotti et al, IEEE NSS Conference, Valencia, Spain, 2011].

Solid State Detector Lab

The hardware infrastructure of the solid state detector laboratory in bldg.28 was maintained and part of the control software for the setups was modified to offer, on the one hand, improved user interfaces with a wider range of measurement parameters for the various batch measurement modes, and, on the other hand, higher flexibility in data representation, storage and analysis. The lab offers the following equipment: Two LHC-Beetle based Charge Collection Efficiency (CCE) measurement systems (ALIBAVA) that can be cooled in dry air atmosphere down to about -30˚C; two Transient Current Technique measurement (TCT) systems using red and infrared picosecond laser pulses. One TCT system operating in standard mode and one in edge mode (edge-TCT); two CV/IV measurement systems of which one can be cooled down to -40°C. Part of the equipment was made available to external groups. Colleagues from ATLAS, CMS, LHCb, NA62, RD39, RD50, LePix and LHC-BCM performed measurements for their individual solid-state sensor projects in the laboratory.

Bond Lab

The main efforts in 2011 concerned the CMS silicon sensor upgrade studies, Medipix bonding (Mpx2, Mpx3,Timepix), ATLAS pixel R&D (sensors and read-out chips), RD50, RD51, NASA, and NA62. As usual there were a large number of smaller jobs from a large variety of clients: PH/ESE, ILC detector (tracker, ECAL), LHC beam condition monitors, CMS HCAL electronics, etc. In addition to the standard gluing and wire bonding activities, an increasing amount of time was spent giving advice and assistance for detector construction and connectivity issues to several projects, especially the LHC upgrades. The lab is pleased that our former full-time QART technician was offered and accepted an LD post to be shared 50-50 between the Bond lab and QART lab.

Quality Assurance and Reliability Testing (QART) Lab

The QART lab, a DT based service since 2010, continued its many activities. Based around a high-end environmental chamber, powerful vibration test system, a small aperture high field (2T) electromagnet, and numerous smaller specialized test equipments, the lab has been used by the LHC experiments for understanding the existing detectors as well as doing tests on prototypes for the upgrades. In addition, many non-LHC experiments and projects have benefitted from the resources of this new lab: Medipix, NA62, CERN radioprotection, CLIC R&D, among others. Research being finalized by the QART lab scientists include studies of bond wire damage from resonant vibration in magnetic fields, further tests of reliability of new metallizations of PCBs, and studies of risk to silicon detector modules from vibration and shock encountered during transport and handling. One PH technical note on PCB metallization reliability was published. As always, we continue to add to our library of QA and reliability testing documentation, procedures, and standards.

The QART lab organized a two-day workshop that took place on 2-3 November 2011. The Workshop, on Quality Issues in Current and Future Silicon Detectors, focussed on learning from the LHC experiments silicon detector construction experience so as to better prepare for the next generation of silicon detectors.

The workshop was a success with over 120 participants and 30 speakers from many different countries and experiments. Workshop details including presentations can be found on the Workshop website: https://indico.cern.ch/conferenceDisplay.py?confId=148944

DSF (Departmental Silicon Facility)

Alice pixel, CMS silicon tracker upgrade, LHCb VELO2, and Medipix were active users of the DSF clean room in 2011. Longer term usage of the facilities will be discussed with the LHC experiments and other interested users when the future plans become clearer. Until then the DSF is open to short-term smaller scale projects needing clean room facilities.

The DSF, Bond lab and QART lab were heavily involved in the 2011 EDIT (Excellence in Detectors and Instrumentation Technologies) school held at CERN from Jan. 31 – Feb. 10. The facilities, equipment, and personnel contributed to the success of this unique school for graduate students and post-docs. Several teaching and hands-on sessions were organized and conducted by the Bond and QART lab personnel.

Thin Film and Glass (TFG) lab

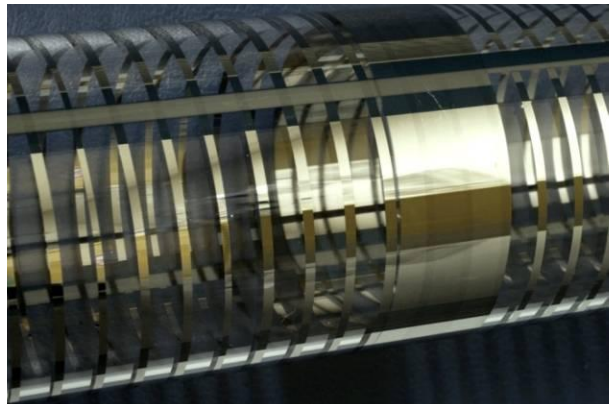
In 2011 the Thin Film and Glass lab continued to provide support to the different CERN experiments in terms of thin film coatings and glass/ceramic machining.

Our specialized Workshop is equipped with several dedicated diamond tools for hard material machining (CNC high speed milling machine, turning machine, different circular saws, drilling machine etc). This allows us to deal with specific materials such as glass, pyrex, quartz, sapphire, ferrites and different ceramics. In 2011 several prototypes and small series have been machined for ISOLDE, NA62, CLIC, micro channel cooling and Medipix. Our Workshop has become a reference at CERN for this type of specific machining.

The Thin Film activity covers the large field of Physical Vapor Deposition (PVD) based coatings. Metals, dielectrics and also organic materials can be evaporated (see pictures).

Major developments over many years have improved two particular applications for High Energy Physics detectors:
UV enhanced spectral reflectors (mirrors): For the reflection of Cherenkov light (UV) in different detectors. These Al/ MgF2 coatings are in very high demand. Since 2011 we have a big ongoing production of reflective Mylar foils and mirrors for the NA62 RICH and CEDAR detectors.
Coatings with Wave Length Shifting (WLS) materials: Evaporation of organic materials like CSI, P-Terphenyl and TPB allow the shifting of light to the required wavelength. These coatings are mainly used

on PM's, Cathode planes and diffuse reflectors, for example, the ALICE Rich and ArDM benefited in 2011 from this technology.

***Photos**: For the CLOUD Experiment, 2 quartz tubes have been partially coated with titanium to dissipate electrostatic charges on the surface.*

Gluing service / Optical lab

The optics and gluing/composite laboratories have provided support for various activities: beam alignment and W calorimeter for CLIC, IBL for ATLAS, RICH for NA62, etc.

Scintillator service

The scintillator service continues to be faced with a relatively low but continuous demand. Typically one request per month is received. The clients come from PH or other departments (e.g. LHC beam instrumentation), a certain fraction are CERN users. The jobs range from simple scintillator tiles, with fish tail light guides for a test beam trigger, to more complex objects, as for the AEgIS experiment. Since 2011 the service is run by a technician who spends about 10% of his time on this work. Damage to expensive diamond tools and other equipment forced us to apply a more restrictive access policy for clients who want to use our machines.

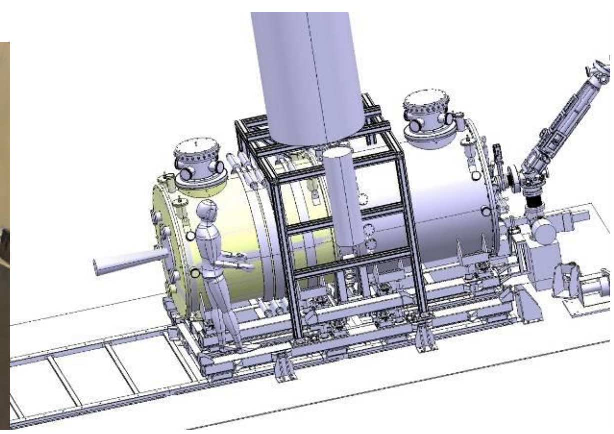



***Photo left**: Large semicircular scintillator bows for the AEgIS experiment. **CAD image right**: The Aegis experiment with the scintillators mounted..*

Gas systems

This has been a very busy year, in addition to the routine maintenance and operation of the gas systems in all LHC experiments, an important number of upgrades to those systems and new projects have been accomplished.

The gas systems for the LHC experiments have proven to be extremely stable; however, we are always working in the direction of increasing further their reliability. For instance, in addition to normal maintenance activities, the circulation pump modules have been significantly improved in order to be able to perform regular interventions without disturbing the detector operation. In collaboration with a supplier, a pump that requires 4 times less interventions has been developed.

On the controls side the EN department, in collaboration with a supplier, has also fixed an issue concerning the stability of the PLC's. The quality control of the gas mixture delivered to detectors is always an important point. Significant progress in the stability of the standard gas analysis modules installed in all the LHC experiments has been achieved. For some critical cases, permanent installations for gas chromatographic analysis have been installed.

Several new systems have also being designed, constructed and installed. A CF_4 recuperation plant for the CMS-CSC detector has been completed and soon will be fully operational. The gas system and distribution units for the new test facility in Bldg 904, for the upgrade of the CMS endcap muon system has been successfully completed. The team has also offered support to several test beam facilities for different detectors (VHMPID, GSI-RICH, RPC, detectors at GIF facility, TPC).

The construction of the CLOUD gas systems is an interesting challenge since the requirements from the experiment are always extremely stringent in terms of gas purity. During 2011 the main activities were related to the construction of an ultra-pure water generator (based on the reaction between H2 and O2), the modification of the trace gas injection system and, finally, an important effort has been put in the implementation of a system able to maintain the chamber in overpressure even in case of power-cut or other critical failures. The latter system is fundamental because several days of cleaning procedure are required in order to recover the standard high purity level after the chamber gets contaminated from the outside air due to an under-pressure event. This can compromise the data taking that normally lasts just about 2 months per year.
Design capacity has been put into the NA62 experiment. The layout of the gas systems for the Straw tracker, the CEDAR and RICH detectors is in place, and the Straw tracker gas system is already in production.
In terms of infrastructure, a new gas calibration laboratory located in Bldg.256 has been fully commissioned. Calibrations for digital Bronkhorst Mass Flow Controllers, for channel flow meters, for pressure sensors and gas analysers can now be carried out and further improvement will take place in 2012 in view of an intense maintenance activity foreseen for these devices during the LS1.

Instrumentation & Control

The year 2011 was marked by the long running periods of the LHC and consequently confirming the very good reliability of the ¨Magnet Control Project¨ equipment, allowing an availability of all experiment magnets close to 100 %.
Even though parts of the equipment have now been in operation for close to 10 years, problems or breakdowns have been virtually non-existent and continuous maintenance and upgrades allow us to be confident for the vital year to come. The stand-by duty service of MCP, consisting of technicians from PH-DT-DI and experiment magnet groups, is no stranger to this. Taking care of the common MCP

systems, it is also a central trouble-shooting point for most services involved in the running of the complex magnets, with many alarms being first handled by the MCP service and then followed through to the solution with the others.
The team has not been idle during the run periods, with a range of external projects demanding full attention, with instrumentation and control participation in most of the group projects (STRAW, AeGIS, E-Gun, TOTEM, ArDM, etc.) on top of the main MNO activities.
In June 2011, the two separate ¨Field Support Units¨ in the group were joined to form the FSU PH-02. This occurred during the change of FSU consortium and resulted in one of the largest units at CERN. The goal of having a reactive and versatile unit within the group has been reached, witnessed by an increasingly large participation in group projects alongside MCP technicians. A certain synergy with other FSU's has also been created, allowing for a better work distribution outside the main shut-down periods.
An activity demanding both MCP and FSU personnel was the upgrade of the ATLAS vacuum system, with novel new pump configurations and a thorough upgrade of the control system.

Publications involving PH-DT-DI members:

- G. Olesen, L. Deront, S. Ravat, A. Dudarev and H. H. J. ten Kate: ¨ATLAS Magnets Quench Protection, Safety and Controls System Experience¨. Paper and poster presented at the MT-22 Magnet Technology conference, Marseille-September 2011. Ref: IEEE MT22-4KP2-12

Magnetic field measurements

Field mapping:

LHCb: The magnetic field close to the beam line was mapped with a specially designed bench (see photo) with measuring head carrying 6 B-sensors. It was using the new mBATCAN read-out system and monitor software.
ATLAS: The Morpurgo magnet was mapped with a device carrying seven B-sensors mounted in a cross.
MICE: Benches for AFC (2 m) and SS (5 m) superconducting solenoids have been built to map the field of max 4 Tesla. A device with a pneumatically rotatable head carries seven 3D B-sensors, calibrated at 4.5 Tesla with a special device at LCMI, Grenoble. Also a DAQ system has been built and control software written.

B-sensor calibration:

The new 3D calibrator in the 2.5 Tesla PT7 magnet is further improved. A new head which fits into the smaller gap of the PT7 magnet was made. This head has new coils which are better centred and has improved electronics. Changes to the on/off-line software were made, as a result the calibration process became more precise and faster.

B-sensor DAQ system:

A programmer started working on the Software of the mBATCAN-system. The goal is to have Windows and Linux Apps with all the functions necessary to operate a B-sensor system of any possible combinations of BATSPI, BATCAN and mBATCAN modules. A simple form has already been used for the LHCb and ATLAS-Morpurgo mapping and the ALPHA monitoring system.

HALL probe test station:

To exploit the high precision of our 3D calibrator, extremely stable Hall sensors are needed. To test the stability of the sensors on large samples, a special device was built for the VARIAN magnet, which measures the main component of 36 Hall probes at the time. The temperature of the device is controlled by water flow. Once the stability of a Hall probe is confirmed it can be mounted in a 3D sensor and calibrated. With this device we also hope to find accelerated burn-in procedures. We will try to give feed-back to manufacturers of Hall probes to improve the stability of their products.

New 3D bench:

A new 3D bench has been designed to replace the old one which in 15 years of service has measured many magnets and is now worn out. In addition it uses non-serviceable components. The old measuring head will be replaced by a new one, compatible with our 3D high precision calibration technique. The new bench has a higher range and better metrological precision. The mechanics has been tested and waits for new motors, drives and a motion controller. After assembly the new 3D read-out can be tested.

Magnetic facilities:

Many clients have made use of the magnetic test facility in 2011: Magnets MNP17 and MNP24 had 9 users and 27 days of occupation. Loan of material (Gauss meters): 6 users, 46 days of loan.

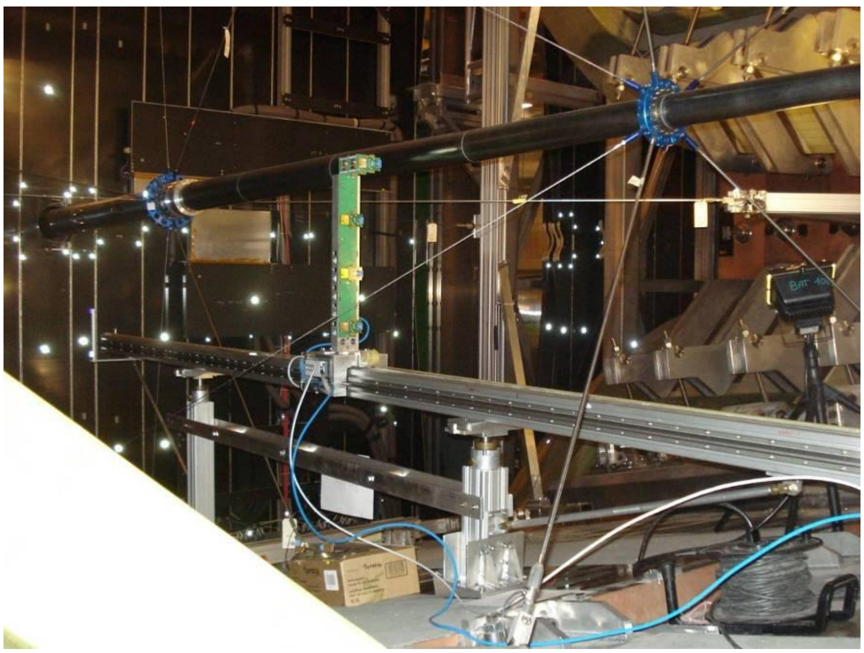


***Photo**: LHCb magnetic field mapping near beam line with custom designed bench.*

R&D on cooling systems for experiments

The main activity on R&D for cooling has again been the development of CO_2 systems. Two prototypes of the innovative 100 W compact cooling device for laboratory applications (“TRACI” for Transportable Refrigerating Apparatus for CO_2 Investigations) have been successfully constructed and commissioned. They are presently in use by LHCb and ATLAS teams. A CERN-NIKHEF co-owned patent for the design of this unit has been filed and possibilities of commercial exploitation are being presently sought with the CERN KT group.

The design of the larger 1 kW unit, started in 2010, has been finalized and fully engineered. A first unit, built in collaboration with MPI Munich, is presently in its assembly phase. This unit is also developed as a prototype of the final ATLAS IBL cooling plant.

***Photo**: The first two TRACI prototypes ready for delivery*

The development of thin micro-structured silicon plates as devices for the local thermal management of tracking detectors have been pursued. A solution suited for the cooling of the NA62 GTK module has been finalized and has been adopted as its baseline by the NA62 collaboration. The proposed solution has been proven to be able to keep the surface of GTK silicon sensor in operation at a temperature of -12±2 °C with a coolant temperature on -20 °C and an additional material budget in the sensitive area of the order of 0.12% X_0. This extremely efficient performance comes in addition to the suppression of all problems of CTE mismatch between heat source and heat sink, and to the extreme flexibility to adapt to different geometries and detector specification. Specific studies for the upgrade of the LHCb Velo and of the ALICE ITS are presently ongoing

A first generation of new humidity sensors, based on optical fibres has been developed, characterized, and proven to be radiation tolerant. This is based on a controlled Polyimide coating of FBG grids distributed along a fibre. This allows for tens of independent humidity measurements along a single fibre with no EM-noise uptake and no need for additional cabling. A set of 80 sensors has been purchased by CMS, with the aim to install during LS1, and is presently under characterization by PH/DT. The R&D presently concentrates on two different enhanced solutions pursued for the production of a second generation of sensors; results are expected for the end of 2012.

Mechanical workshops

The DT group has eight mechanical workshops of which three are dedicated to support DT service activities like thin films and gas systems. The five other workshops include point 1 and 2 workshops and general purpose workshops for, example, the production of prototypes, complex assemblies, and quick fixes during detector assembly phases.

These workshops provide work-space, machines and tools for the project users of visiting teams. In 2011 the main investments were made to improve safety and working conditions, e.g. a new fire-safe dust removal system was procured and installed for a 2-meter wide planar grinding machine.

Research & Development

R&D on Radiation Tolerant Silicon Sensors

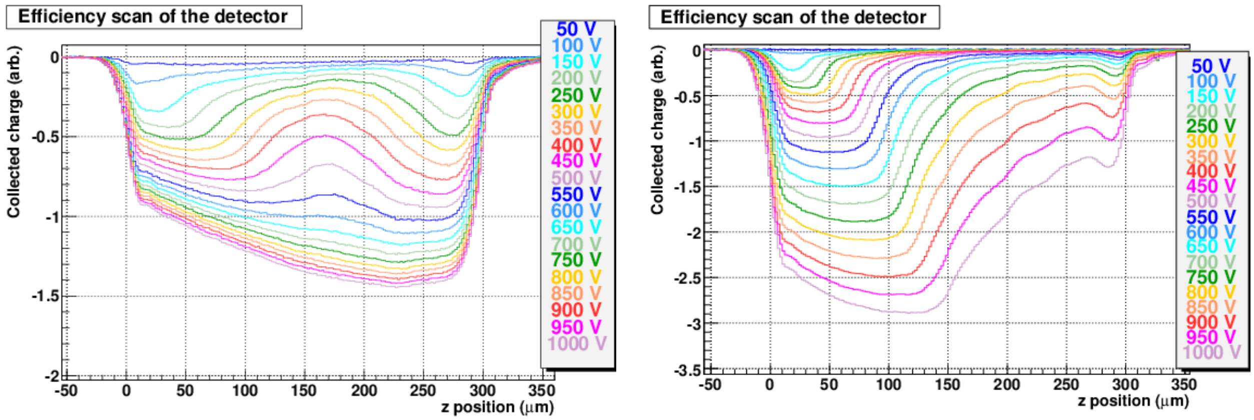
The PH-DT group participated in the framework of the CMS Phase II Tracker Upgrade and the RD50 collaboration in R&D activities related to silicon sensor developments.

For the CMS Tracker project on the qualification of Hamamatsu Photonics K.K. (HPK) sensors for the phase II upgrade about 1000 CV/IV and about 1000 TCT measurements were performed in the PH-DT laboratory in 2011. The measurements were performed mainly on diode test structures and served to verify the quality of the test structures and to inter-calibrate the measurement setups and measurement procedures of the participating CMS tracker groups. A vast measurement campaign on irradiated sensors with varying parameters (silicon material, conduction type, sensor thicknesses, thinning methods, radiation levels) will be performed in 2012 with the aim to give a recommendation for the choice of sensor type and material for the phase two Tracker upgrade. The work in the PH-DT labs, as part of the overall campaign, will remain focused on the characterization of the irradiated diode test structures.

The coordination of the RD50 collaboration (47 Institutes, 261 members) was supported and steered by providing a co-spokesperson, administrative support, the budget holder and the co-ordination of several RD50 common projects.

The PH-DT research program within RD50 focused strongly on the evaluation of p-type silicon strip sensors being presently the most promising sensor type for the phase II tracking detector upgrade. Good progress was made in understanding the evolution of the sensors internal electric field with increasing fluence and annealing time. A key to this understanding was the use of the edge-TCT technique and the corresponding analysis of the data using sophisticated data fitting techniques. The measurement is performed by injecting a picosecond infrared laser light pulse into the polished cutting edge of a silicon strip sensor and measure the time resolved signal on one of the strips as function of the position of the laser spot.

The figure below gives an example of an edge-TCT measurement (efficiency scan) for a p-type strip sensor irradiated with 24 GeV/c protons to 10^{16} p/cm^2. It demonstrates how the evolution of the internal electric field with time is impacting on the efficiency of the sensor. A particular interesting outcome of the presented measurement is that after long annealing times, when the high electric field region is limited to approximately 100 µm underneath the front electrode, still a significant efficiency is observed in the region towards the back electrode. It is believed that this is due to impact ionization processes (charge multiplication) of the traveling charge carriers close to the front electrode. This important result is presently under study within the RD50 community, as it is the key to the surprisingly good performance of p-type detectors (resp. detectors with n-type electrode) after exposure to very high radiation levels, such as expected for the silicon trackers after the High Luminosity upgrade of the LHC.



Efficiency depth profiles of an irradiated p-type silicon strip sensor directly after irradiation (left) and after an annealing of 10.000 minutes at 60˚C. The front electrode corresponds to 0 µm and the 300 µm to the back electrode of the silicon sensor.

Micro-Pattern Gas detector developments

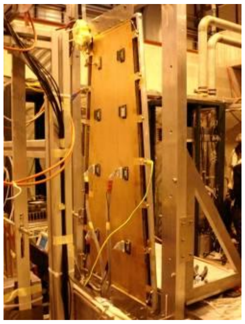
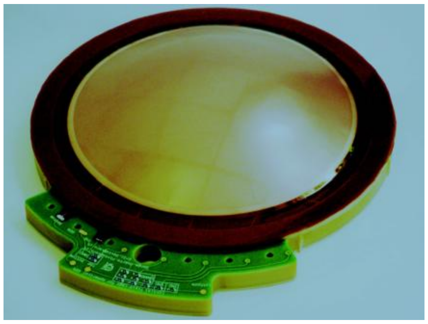
In the framework of RD51 Collaboration (80 institutes from 25 countries, 470 participants) the PH-DT group participated in the development of advanced gas-avalanche Micro-Pattern Gas Detector (MPGD) technologies and associated read-out systems for applications in basic and applied research. MPGD detectors offer unprecedented spatial resolution, high rate capability, large sensitive area, operational stability and radiation hardness.

The RD51 research programme in 2011 concentrated on the detectors characterization, applications, software and simulations, development of electronics, production and beam tests of large-area MICROMEGAS, Gas Electron Multiplier (GEM), and Thick-GEM detectors.

Major achievements include: a) the construction of large-area MPGDs with 1 m^2 unit size, which could be used potentially for the ATLAS and CMS Muon System upgrades; b) the successful completion of the first RD51 Common Project (Scalable Read-out Systems); c) progress with the upgrade of the CERN MPGD workshop; d) major improvements to the MPGD simulation software in the domain of small-scale structures and e) first steps towards industrialization of the GEM and MICROMEGAS technologies.

PH-DT supported coordination of the RD51 Collaboration by providing co-spokesperson, administration and budget management and coordination of several common projects including organization of the meetings, conferences, schools and laboratory and beam test campaigns.

The group continued generic R&D, focusing on the completion of the development of the spherical GEM detector for X-Ray diffraction application and optimization of the MPGD detectors performance for the TPC readout.

(a)  (b)  (c) 

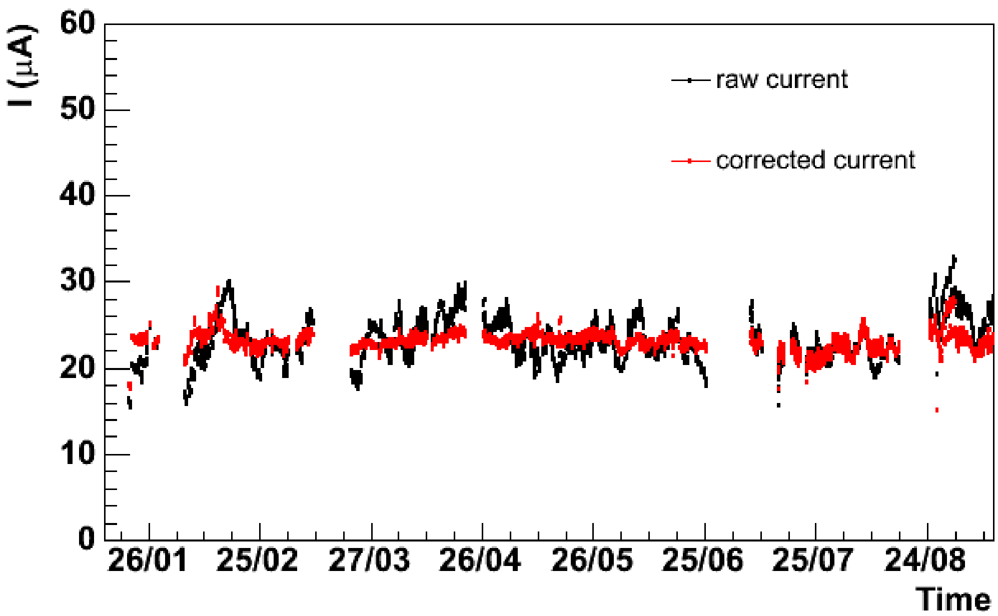
***Photos**: Large area MPGD detectors and detector components (a) Micromegas or ATLAS, (b) GEM for CMS and (c) spherical GEM for X-Ray diffraction application, developed within RD51 Collaboration with participation of PH-DT group.*

Long-term study of optimal gas purifiers for the RPC systems at LHC (WP7)

This study investigates the impurities produced in the gas of heavily irradiated RPC chambers and the properties of possible purifiers for the closed-loop gas systems used in the LHC experiments. The goal is finding the operational conditions that will keep the RPC gas purity near the level of the fresh gas quality to ensure proper operation of the large RPC systems at high luminosity.

The properties and performance of a large number of purifiers have been understood. On that basis, an optimal combination of different filters consisting of Molecular Sieve 5Å and 4Å, and a CuO catalyst R11 has been chosen and validated irradiating a set of RPC's at the CERN Gamma Irradiation Facility (GIF) for several years. The performance of these heavily irradiated RPC's seems to be unaffected at long-term by the achieved low concentration of impurities (<500 ppm of freons and hydrocarbons). After correction for changes due to environmental conditions (current fluctuations induced by pressure and temperature variations), the currents drawn by the RPC's connected to the optimized closed-loop gas system have been very stable over the entire test period, as seen in the figure.

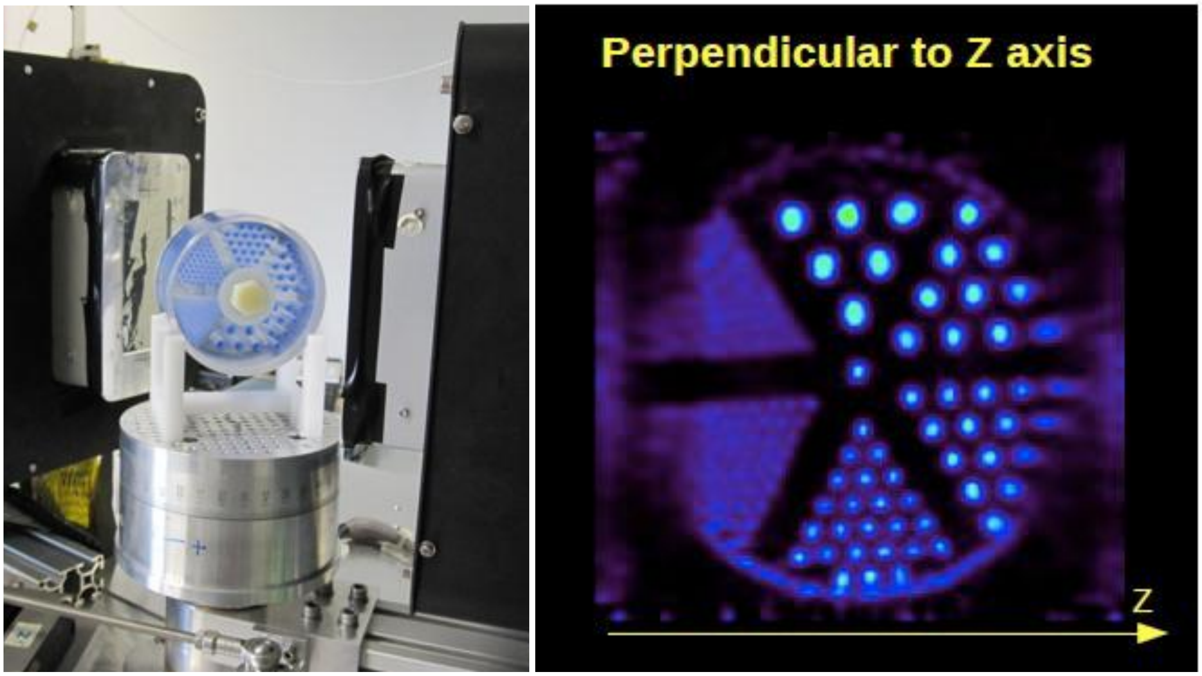
Another important feature of this new filter configuration is the increase of the cycle duration for each purifier, which results in better stability and reduced downtime of the RPC gas systems. If needed, it permits to comfortably increase the gas flow in the detectors during the high luminosity running at LHC. This study is now concluded and the new filter's arrangement will be implemented in the RPC gas systems during the long technical shutdown LS1.



The raw and corrected current drawn by the irradiated RPC's during the several months test period of the final optimized configuration of filters.

AX-PET

AX-PET is a medically oriented project which focuses on the demonstration of a novel geometrical principle for Positron Emission Tomography. The AX-PET technology produces PET images that are practically free of parallax errors. This is possible thanks to the axial arrangement of elongated scintillation crystals combined with the wavelength shifter readout of the transverse co-ordinate. In 2011, the AX-PET set-up was further improved and profited from an improved data acquisition speed and a good modelling of the systems efficiency. Sets of high quality data, incl. new phantoms, were taken at the company AAA (Saint Genis Technoparc). The system hardware and the image reconstruction software has now reached a level of performance that we plan for 2012 tests in a pre-clinical environment with small animals (mouse or rats) at the ETH Zurich.



Measurements at AAA with a FDG filled resolution phantom (produced in the DT workshop). Right hand side: Reconstructed image. The smallest resolved channels have a diameter of 1.6 mm and 3.2 mm between centres.

Other Activities

MC-PAD

MC-PAD is an EU funded Marie Curie Initial Training Network (ITN) with 22 positions for doctoral and post-doctoral researchers. Four of the positions (CERN fellows) are located in the DT group. Founded in November 2008, the network has a total volume of 4.7 M EUR. In 2011, three fellows ended their contract as foreseen, the fourth position continues until end of 2012. The network organized two training events (3 days each), one at CERN and one at PSI. During the CERN event, a total of 40 participants received lectures and practical training on gas and photon detectors. A member of the group is in charge of the network coordination.

EIROforum

The instrumentation working group of EIROforum (CERN, EMBL, ESA, ESO, ESRF EFDA/JET, ILL and since 2010 XFEL) organized the 2nd EIROforum School of Instrumentation, held in May 2011 at the ESRF Grenoble, with about 60 participants from across Europe. Several DT physicists contributed as lecturers on tracking detectors, calorimetry and photon detectors, helping to make this school a real success. The Marie Curie proposal EIROnet was unfortunately unsuccessful also in its resubmitted (Dec 2010) version.

Summer students and summer student workshops

In 2011 the DT group hosted several summer students in various working fields ranging from analysis of first data from ATLAS ALFA to the characterization of silicon sensors for the phase II upgrade of CMS. In parallel to these projects, the DT group organized a part of the 2011 Summer Student Workshops which offer the chance to gather hands-on experience on beam line and particle detector elements as well as data analysis tools. In total 9 groups of students were trained by PH-DT in 3 courses. The course "Measurements with scintillating fibers" focused on the study of the scintillation emission spectrum, light absorption length, reflective coating properties and photo detectors. In the course “Time-of-flight” the students performed measurements with vacuum photo-detectors containing a micro-channel-plate obtaining a timing resolution of the order of 50 ps. The course “Silicon sensors” taught the basic working principles of silicon detectors and gave an introduction to performance degradations arising from radiation damage. Finally interconnect techniques were explained and demonstrated in the PH-DT bonding laboratory.

EDIT school

The first edition of the Excellence in Detectors and Instrumentation Technologies (EDIT) School took place at CERN from 31 January to 10 February 2011.

The school organized by A. Cattai, combined lectures with 36 hands-on laboratory activities in six different fields of detector and instrumentation techniques. The subjects covered include calorimetry, electronics, gaseous detectors, detection of scintillation and Cherenkov light from crystals and fibres, photodetection, silicon strips and pixel detectors. Tutors came from various CERN Member State Institutes, and DT played a very important role. C. Joram chaired the photo-detector laboratory, where 6 different hands-on activities addressed key aspects of photo-detectors. T. Gys, for instance, mounted a setup for single photon counting measurements. M. Moll co-organized and hosted the labs on silicon strip technologies and pixel technologies. More than 10 different hardware activities were proposed, among them A. Honma organized a set up on wire bonding, interconnect and reliability testing. M. Capeans was the convener of the Gas detector lab, where 9 different hands-on set ups were organized. H. Danielsson led a set up on straw detectors and their front-end electronics, using NA62 hardware. L. Ropelewski led a lab on micro-pattern gas detectors, with 3 different experimental setups on GEM, micromegas and GridPix. R. Guida mounted a setup with RPCs. The hardware setups were complemented with a successful set up on simulation techniques chaired by R. Veenhof.

The quality of the tutors, the state-of-the-art teaching set-ups and the intensity of the workshops with one tutor per student was a fantastic opportunity for more than 80 young scientists and engineers.

***Photos**: Rolf Heuer (CERN Director General) and Pier Oddone (FERMILAB Director General) visiting the EDIT Labs on gas detectors (left) and silicon detectors (right). The two labs were setup in existing DT facilities, the detector assembly hall and micro-pattern gaseous detectors lab in B154 and the PH-DT Silicon-facility in B28.*

Representation in CERN working groups/committees

The DT design office in building 25 provided working space and support to several visiting designers and engineers, working in the various projects the DT group is involved in. In addition to their daily project involvements the DT Project Office staff had key roles in the following PH- and CERN-wide engineering committees and working groups: Computer-Aided Engineering Committee (CAEC), Groupe d'Utilisateurs Catia-SmarTeam (GUCS), CAD Use in Experiments (CADEX), and Computational Structural Analysis Committee (CoSAC).

Selection of publications involving DT members

I.Mandic et al., The Effect of Magnetic Field on Readout of Diodes Used as NIEL Counters; IEEE Trans. Nucl. Sci. 58 (2011) 1112-1116

N.Pacifico, I.Dolenc Kittelmann, M.Fahrer, M.Moll, O.Militaru, Characterization of proton and neutron irradiated low resistivity p-on-n magnetic Czochralski ministrip sensors and diodes; Nucl. Instr. & Meth. in Phys. Res. A 658, 55-60 (2011)

C. Joram, Photodetection in the LHC experiments, Nucl. Instr. & Meth. in Phys. Res. A, in Press

P. Beltrame et al., The AX-PET demonstrator—Design, construction and characterization, Nucl. Instr. & Meth. in Phys. Res. A 654, (2011) 546-559

M. Villa et al., Progress on large area GEMs, Nucl. Instr. & Meth. in Phys. Res. A 628 (2011) 182-186

M. Capeans, I. Glushkov, R. Guida, F. Hahn, S. Haider, Optimization of a closed-loop gas system for the operation of Resistive Plate Chambers at the Large Hadron Collider experiments, Nucl. Instr. & Meth. in Phys. Res. A 661 (2012) 214-221

T. Gys, R & D status for the LHCb TORCH project, 2011 JINST 6 C10004.

R. Cardinale et al, Analysis and correction of the magnetic field effects in the Hybrid Photo-Detectors of the RICH2 detector of LHCb, 2011 JINST 6 P06010.

P. Martinengo, for the ALICE collaboration, The ALICE high momentum particle identification system: An overview after the first Large Hadron Collider run, Nucl. Instr. & Meth. in Phys. Res. A 639 (2011) 7-10

A. Affolder et al. (several DT members), Silicon detectors for the sLHC, Nucl. Instr. & Meth. in Phys. Res. A 658, (2011) 11-16

M. Fiorini et al., The Gigatracker: An ultra-fast and low-mass silicon pixel detector for the NA62 experiment, Nucl. Instr. & Meth. in Phys. Res. A 628 (2011) 292-295

M. Consales, A. Buosciolo, A. Cutolo, G. Breglio, A. Irace, S. Buontempo, P. Petagna, M. Giordano, A. Cusano, Fiber optic humidity sensors for high-energy physics applications at CERN
Sensors and Actuators B: Chemical ISSN: 0925-4005 Vol./Iss.: 159/1 (2011)

J. Kirkby et al., Role of sulphuric acid, ammonia and galactic cosmic rays in atmospheric aerosol nucleation, Nature, Volume 476, 25 August 2011, pages 429-433, doi:10.1038/nature10343

A. Mapelli, P. Petagna, K. Howell, G. Nuessle, P. Renaud, Microfluidic cooling for detectors and electronics
Journal of Instrumentation, Volume 7, Issue 01, pp. C01111 (2012).