Annual Report 2009

29 April 2010 (CJ)

Detector Technologies Group PH-DT

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.

The group is organized in 5 sections.

- 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 about 80 staff and 20 fellows and students. We collaborate with two Field Support Units (FSU) in the gas systems and controls activities. Most of the group 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 2009 the group's activities were concentrated in four areas:

1. Completion and consolidation of the ongoing LHC projects;
2. Maintenance and operation: 'on-call' services, shutdown and preventive maintenance, repairs for detector systems and infrastructure;
3. New detector projects: participation in new developments (LHC upgrade, non-LHC experiments);
4. R&D: participation in common R&D activities in strategic fields.

While the structure and mandate of the group were identical to the previous year, our activities comprised stronger non-LHC (CLOUD, Aegis, NA62) and increased R&D components. About 50% of the resources were (directly or indirectly) allocated to the LHC activities of the first two areas. The non-LHC activities consumed about 15% and R&D about 25% of the resources (the latter mainly being fellows and students). About 10% of the resources are needed for general service tasks (workshop supervision, safety and management).

Detector Projects:

AEGIS

During the past year the Aegis project made important progresses in the definition of the general layout of the experiment and in the design and integration of the different components. The manufacturing of the first parts started and some preparation works were carried out in the experimental area in building 193.

The layout of the experiment is now well advanced and the detailed design of the different components is under way. The design is carried out in collaboration with the TE/CRG group for the

cryogenic elements, the TE/VSC group for vacuum related problems and the EN/MME group for the definition and qualification of the welds.
For what concerns construction, the priority was given to the first parts necessary during the installation and commissioning, namely the superconducting solenoids and the related cryostats. The superconducting cable and the winding supports have been purchased and delivered. A winding machine has been designed and built by members of the DT group and the winding will start during the month of April 2010.

Figure 1 : Left hand side: The winding machine and the winding work shop in building 164. The winding support for the 1T solenoid is in position (the brown cylinder) and the spool of superconducting cable is ready (the orange cylinder partially covered by protection pasteboard). Right hand side: Machining of the winding support for the correction coils in a CNC lathe.

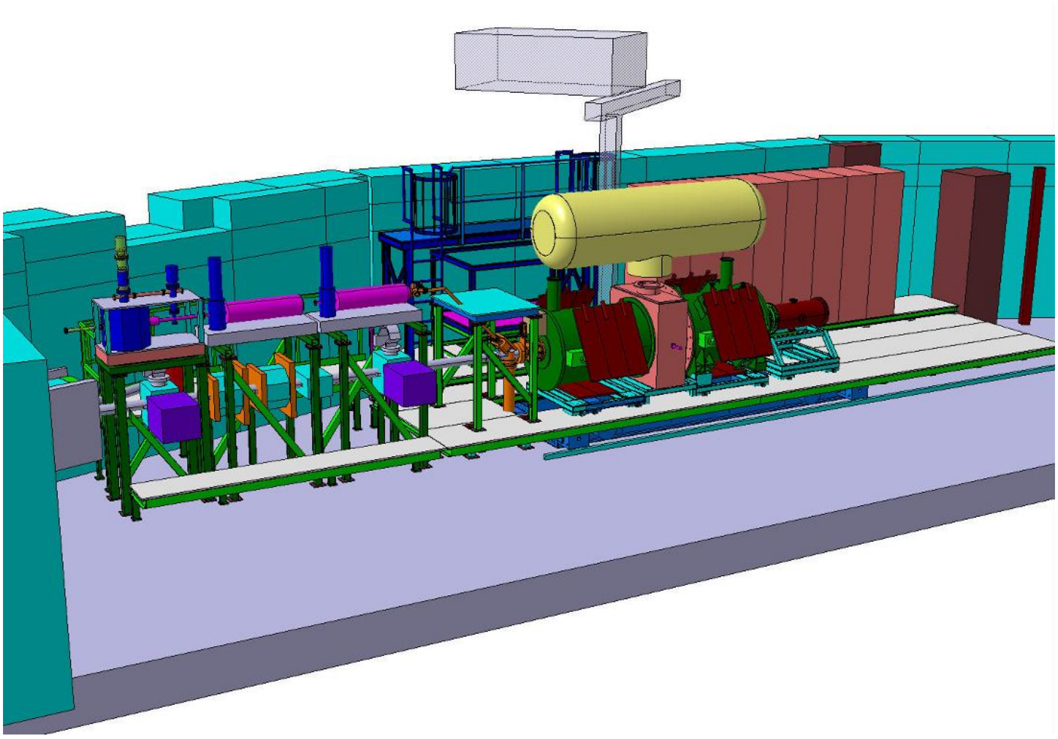

Figure 2 : CAD integration studies were made for the layout of the experimental area at the AD.

ALICE
ANSYS simulation studies were carried out and models and drawings were produced for the "TPC parking frame" of ALICE. Design and calculations were performed for the mechanical strength and

stiffness of the additional support devices for the TOF detectors in the ALICE experiment. These devices have been produced and installed.

Figure 3: ALICE TOF supports

ATLAS ALFA Roman Pots

The supports for all the Alfa stations were installed in the tunnel. One complete station has been installed in the tunnel. A pre-design has been made to modify the compensation system on the 3 other stations to compensate for an unforeseen geometrical mismatch with a special section of the QRL system. A wooden mock-up has been designed and fabricated which is used by technicians to exercise detector insertion.

The ALFA detector integration was largely finalized and the series production phase of the scintillating fibre detectors was launched. DT personnel participated in the preparation and running of a successful test beam experiment in the SPS H6 beam line. The first full ALFA detector was installed in the tunnel in January 2010.

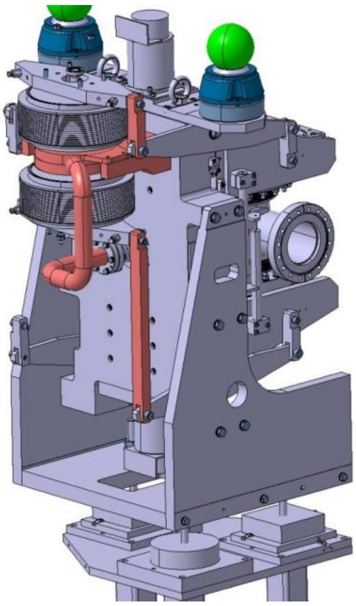

Figure 4: Modified ALFA Roman Pot mechanics, compatible with the QRL section.

ATLAS Inner Detector

The team was involved in the opening and closing of the ATLAS Inner Detector for maintenance in February and March.

For the Inner Detector, CAD models and drawings were converted into the CATIA format from different, original versions (Euclid and worldwide by the ID collaboration).

Engineering support was provided for the integration studies for the future inner detector B- layer.

Engineering studies were made for the Atlas SLHC Tracker upgrade project. This included 3D CAD modeling of the complete inner detector. The compilation of the inventory of services was used to model services and was supplied to detector groups for physics simulations.

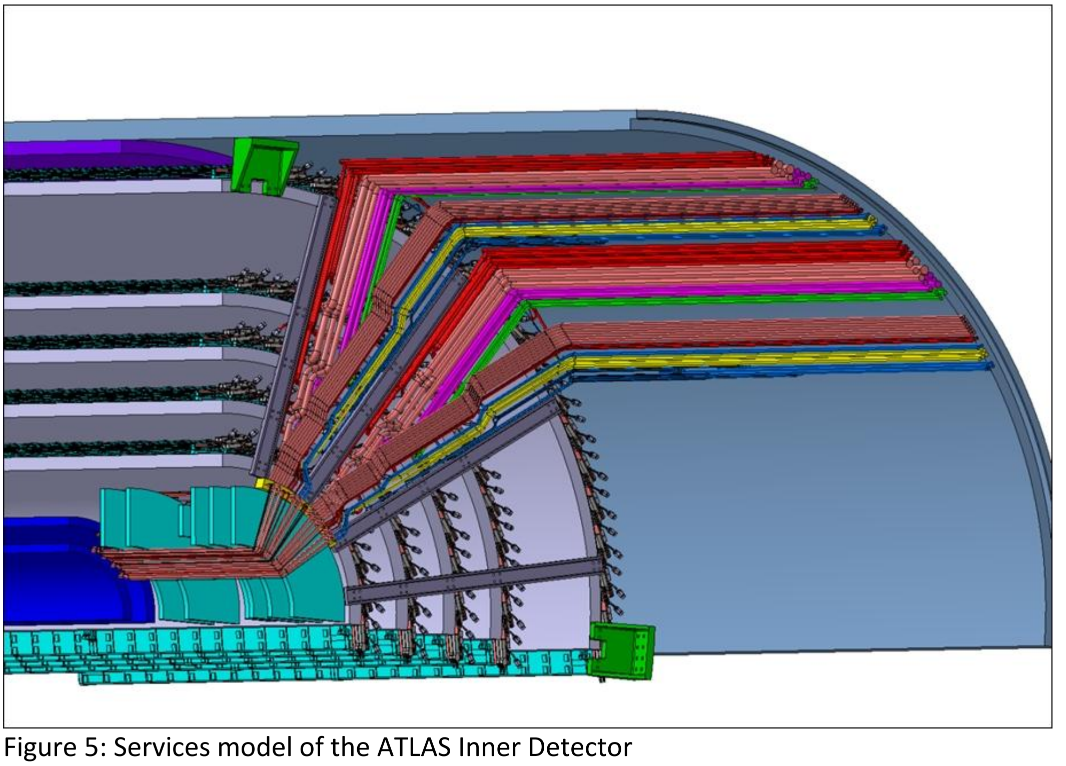

Figure 5: Services model of the ATLAS Inner Detector

CAST

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

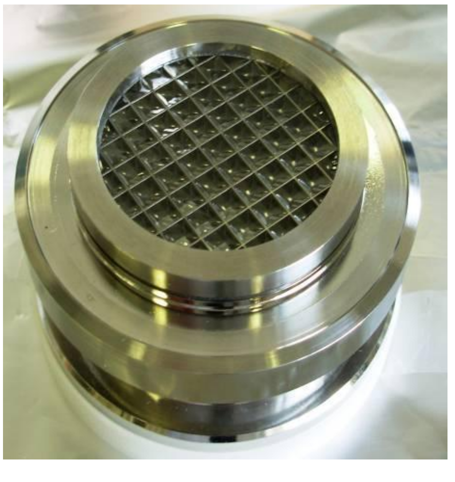

Figure 6 : CAST, cold X-ray window

A group technician prepared and glued 4 thin X-ray transmitting windows ('cold windows') for installation in the experiment in April 2009 in preparation for the high pressure ^{3}He running of CAST. These windows operate at temperatures between 15K and 60K and separate the ^{3}He buffer gas in the magnet cold bore from the vacuum pipes leading to the X-ray detectors outside the cryostat. They must withstand quenches of the magnet where the pressure on the window can rise towards 1 bar in a few seconds.

They were made from 316LN flanges electro-eroded to produce a 'strong-back' support grid for a thin polypropylene foil of 15 µm thickness. Before gluing the stretched foil onto the support, the windows flanges were electro-polished in the surface treatment lab. After helium leak testing down to 1.8K in the cryolab, the windows remain leak-tight when subjected to a series of rapid pressurizations up to 2.5 bar of helium at 60K.

The group made a strong contribution to the 2009 upgrade of the CAST vacuum system in the area of electrical installation of several new pumping systems and their interlock and monitoring systems. Safety interlocks were added to the magnet movement system and to the load pin measurement system.

The year 2009 saw the second year of running with ^{3}He as the buffer gas in the cold bore of the CAST magnet. The complex ^{3}He gas system enabled CAST to make small steps in the buffer gas density half-way through each solar tracking. A total of 247 new density steps were performed from 37.1 to 65.2 mbar @ 1.8K corresponding to an axion rest mass range of 0.64 to 0.85 eV/c^2. Thus the search for the hypothetical axion was extended deeper into the theoretical favoured region.

CLOUD

PH-DT had major responsibilities in the construction of the PS-215 CLOUD experiment, in particular with the design, procurements and construction of the experiment's gas system, thermal system, field cage, and infrastructure.

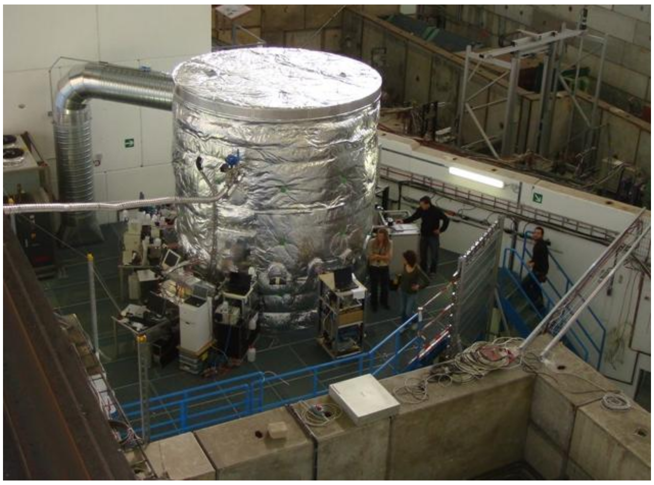

Figure 7 : The CLOUD experiment installed in the T11 area of the PS East Hall.

The work was carried out in collaboration with the EN department, and with other CLOUD collaborating institutes. In addition, a PH-DT engineer worked as the technical coordinator and GLIMOS of the experiment. The intense construction and commissioning period culminated in a very successful physics run in November - December 2009.

CMS

In early 2009, the Preshower subsystem was installed on each CMS endcap. This installation was also an in-situ subdetector assembly, around the beam pipe. This unprecedented task was completed swiftly and flawlessly, thanks to careful preparation in the years before. It has crowned the group's intense involvement in the Preshower project.

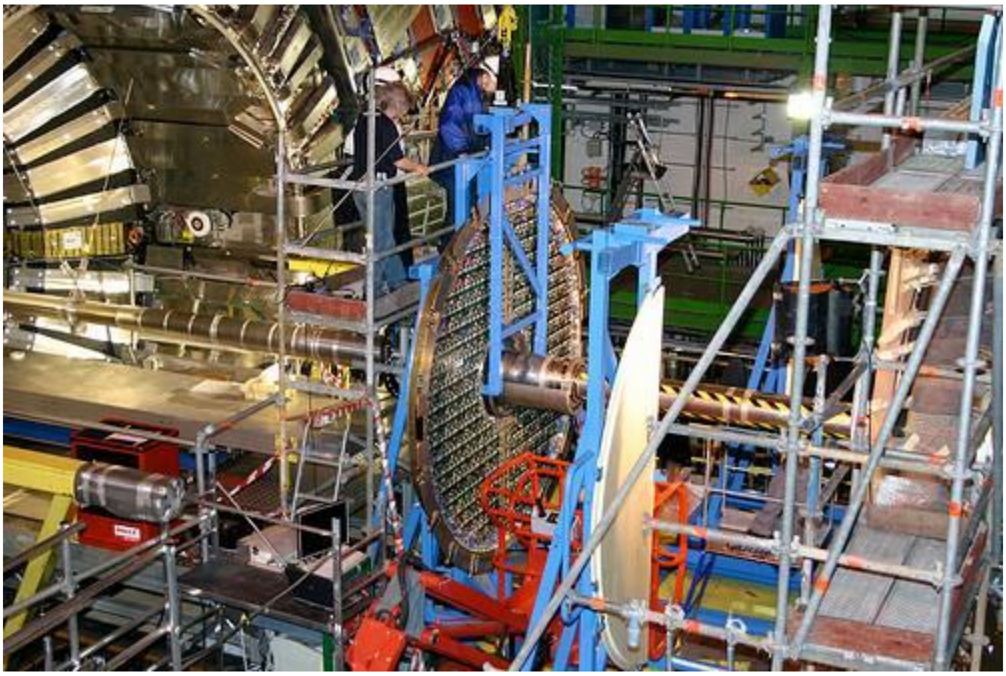
Figure 8 : CMS, installation of the pre-shower detector

Engineering support was given to the CMS tracker (i.e. alignment ring displacement, FPIX removal and reinstallation, beam pipe adjustment, repair of wiring and connections for the thermal screen at the TK end-flange). Members of the PH-DT participated in the leak-search in the 198 cooling circuits of the CMS Tracker. Whereas major leaks had been found earlier in the cooling plants, only two clearly identified leaks were found inside the experiment itself. Detected by gas analyzers sniffing samples from inside the tracker volume these two leaks are located in non-accessible areas inside the silicon strip tracker structures, and limit the continuous use of these two circuits.
The team was involved in the commissioning and operation of the humidity monitoring system.
A PH-DT engineer acts as Mechanics and Thermal system coordinator in the recently established CMS Tracker Upgrade Project Office, TUPO.

LHCb

The DT group has been in charge of the installation of the final Magnetic Distortion Monitoring Systems (MDMS) in the RICH1 detector. It has carried out general operation and maintenance activities, in particular the repair and optimization of the high voltage system, and of the Laser Alignment Monitoring Systems (LAMS) of the RICH1 and RICH2 mirrors. As responsible for LHCb-RICH pixel hybrid photon detectors (HPDs), the group has conducted the replacement in RICH2 of 50 vacuum-degraded HPDs. The LHCb-RICHes have been operating optimally in 2009. In particular, during the start-up phase of the LHC, the RICH performance was excellent, as are showing the preliminary results from the analysis of the first collision data.

The group participated also in the test beam activities for the VELO upgrade project and constructed a novel telescope with double tilted planes to optimize the resolution for the Timepix chip, used as particle tracking device. The telescope achieved 2µm pointing resolution for the Device Under Test, which is a record for a 55µm pitch device. Moreover, a setup was prepared to study the behavior of VELO modules during exposure to high rates of charged particles under various HV/LV conditions at the PS booster. The setup included equipment to image the beam profile with a noryl screen and vortex cooling of the irradiated devices.

Finally, The group coordinated the installation activities for the first station (M1) of the Muon system. In a period of only 4 months all 268 chambers had to be installed, tested and aligned. This was followed by the closing of the station and its commissioning to prepare for the LHC pilot run. The whole Muon system has been time and space aligned with cosmic muons collected in a series of runs. A thorough study of electronics noise has been carried out by members of the group and the optimal thresholds and HV values have been applied. The LHC pilot run confirmed that the Muon system performs very well. The number of chambers (gas gaps) operated below nominal HV is only about 0.1%, and the number of dead readout channels is as well at the 0.1% level. The angular and momentum distributions of muons from the first collision data are in very good agreement with MC predictions.

The LHCb detector is in excellent shape for the 2010/2011 LHC physics run.

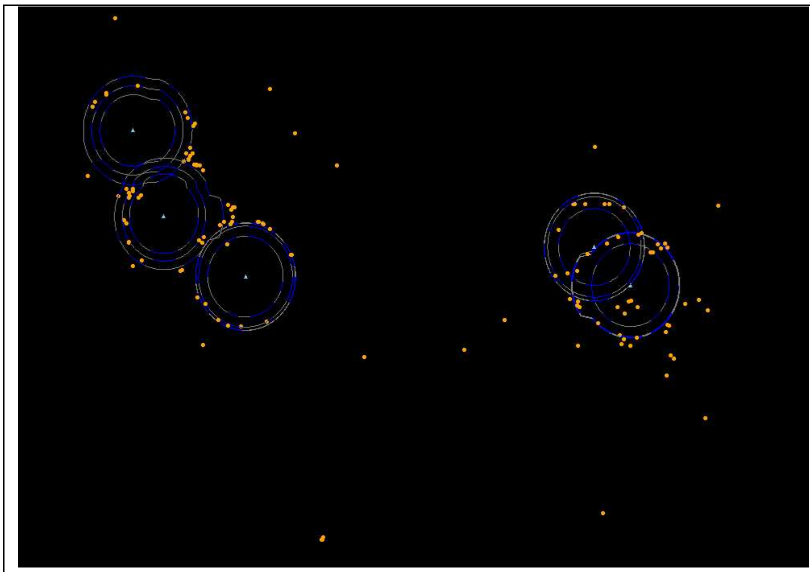

Figure 8: LHCb RICH2 HPD panels with pixels and CK rings

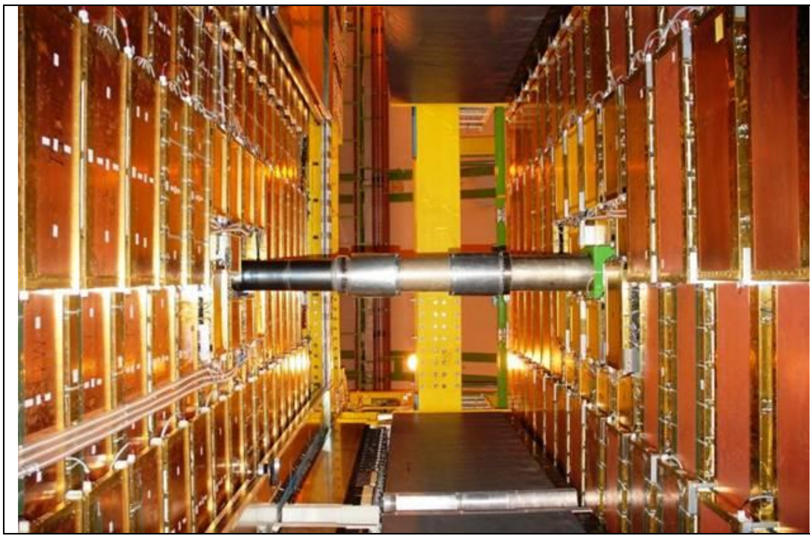

Figure 9: Muon stations M2 (left) and M1 (right) after closing. The LHC vacuum chamber crosses the detector.

Model conversion was carried from Euclid to Catia. The group helped in studies for integration of Rich1 and general integration. Support was given to outside institutes. Studies were made for two prototypes of micromegas detectors.

NA62

The group has assumed responsibility for the design of the vessel of the Ring Imaging Cherenkov pion-muon identifier for NA62 and has started in 2009 first conceptual studies on such vessel of unprecedented size and with non-trivial interfacing.
Detailed CAD modeling studies were performed for the different components of the straw detector: support frames, tube fixations, gas compartments, etc. Some calculations were made and prototype parts were constructed.
The group made CAD model Integration studies for the existing NA48 and the newly configured NA62 experiments. This has involved the creation of new CATIA models from old drawings of existing parts. A 3D model of the NA62 experiment in CATIA is being completed for the integration and installation studies.
Engineering Data Management Activities were initiated to assist with the technical coordination such as EDMS, PBS, Data base, traceability, CDD.

TOTEM

The group participated in the production, testing and installation of the Roman Pot (RP) detectors with full responsibility for all mechanical issues in particular the assembly of the silicon modules with a mechanical precision of +/- 30 microns and the integration of the cooling circuits. After assembly the pots were tested at H8/SPS with a specific set up that allows using alternatively cosmic rays or beaming particles from the SPS accelerator. Finally 12 RP detectors were successfully installed at 220 m in sector 45 and 56 of LHC and connected to the associated services (cooling system, vacuum system). Further 12 RP detectors are ready for installation.

Figure 10: Totem, near station at 220 m

The RP motor systems which allow moving the RPs within the LHC beam pipes were calibrated and tested in close collaboration with LHC. The vacuum equipment for the secondary vacuum in the RP envelopes was installed and tested.

SERVICES

Irradiation Facilities

As in the previous years the PS irradiation facilities were heavily utilized by many CERN groups and external users. The general tendency for irradiation experiments, observed already in 2008, continued: The complexity of the individual irradiation experiments increased while the total number of irradiated objects decreased. Examples for time consuming experiments were irradiations of scintillating crystals that get heavily activated during irradiation, irradiations of silicon sensors up to extremely high fluences while being in a cold environment and irradiations of operating front end electronics with readout systems attached to them. In total 431 objects were irradiated in 142 days of beam time requiring the measurement of 337 dosimeters in order to achieve a proper dose or dose profile for the individual samples. Clients were coming from the ATLAS, CMS and LHCb experiments, the RD39, RD42, RD50 and Crystal Clear collaborations and the RADMON project. In parallel to the irradiation experiments a new support system for irradiation tables was developed and installed. It will allow moving up to 4 independent irradiation tables into the proton beam. A first table was constructed and equipped with a cold box that allows for irradiating silicon sensors at low temperatures. Additionally, some R&D on a compressed dry air driven Vortex cooling system was performed that potentially can replace some of the presently liquid based cooling systems inside the irradiation area.

The Gamma Irradiation Facility (GIF) in bldg. 190 was made available to several users. It was used by physicists working on ATLAS MDT chambers, LHC Beam Loss Monitors and by groups performing aging tests on RPCs in the framework of the “Facilities and Component Analysis for Detector R&D” working group (PH-R&D project WP7). In addition to the regular maintenance of the facility and the irradiation source several smaller activities aiming to improve the safety of the facility were performed.

Furthermore, all personnel of the irradiation facilities participated very actively in the ongoing evaluation and planning for new or upgraded irradiation facilities at CERN. This included e.g. the PH technical coordination for the GIF++ project, a new Gamma Irradiation Facility combined with a SPS extracted particle test beam.

Radiation Monitoring

In the framework of the RADMON project six further RADMON boards were provided to the LHC Experiments as well as 250 dosimeters for passive dose measurements. The stock of spare dosimeters and boards for the LHC experiments was maintained and some R&D focusing on low cost commercial and custom made silicon pin diodes was maintained. The latter was performed in close collaboration with the University Montpellier II and has been published in scientific journals.

Bondlab / Quality Assurance and Reliability Testing (QART) / DSF status

Bondlab activities performed in 2009.

Main effort: Totem (All Roman Pot modules), Atlas-ALFA (85 PMF PCBs), Medipix (Mpx2, Mpx3, Timepix), Axial Pet (gluing), CMS Opto. Other jobs: Atlas (LUCID,ABCN,FEC), PH/ESE (5+ different PCB jobs), RD50, NA62, Compass (silicon strip and RICH detector repairs), Isolde, Alice (Pixel, Upgrade /

Phoenix), AMS, UA9-SPS, CMS Upgrade (sensor studies), numerous other small jobs. Bondlab remains very active.

QART

This is a WP6 activity but it uses the DSF floor space and shares manpower with the bondlab. It will likely become part of the DSF and hence PH/DT at the end of 2010. The equipment procured comprises an environmental chamber, IR camera, vibration test system, shear tester etc.

First studies were made in 2009 using QART equipment. More studies in progress. TOTEM, Atlas, CMS, Medipix, and others have used QART equipment. Another activity is building a library of QA and reliability testing documentation, procedures, standards.

We will convene a QA workshop in 2010 to get input from LHC experiments silicon detectors.

DSF

Only Alice pixel, RD50 and occasionally Medipix are still active in DSF clean room. We are organizing a meeting with all 4 main LHC experiments and other users to discuss usage of clean and non clean room for next 5 years.

Gas Systems

All gas systems of the LHC gas project were operational during the course of 2009. For the first time, an all-year service was successfully provided to the LHC experiments. In LHCb, the RICH detectors represented a particular challenge to bring into final operation due to the heavy and expensive nature of the operational gasses. In ATLAS, the TRT CO2 Forward Cooling gas system, originally not built by the DT group, was incorporated in the overall gas operation of the experiment.

For the CLOUD experiment a new gas system was successfully built and installed. The extreme purity and the addition of minute trace gasses, in the ppb region, were particular challenging goals to meet.

Instrumentation & Control

In 2009 the unit successfully commissioned the control, safety and diagnostics systems in all LHC experiment magnets, thus ending the development and installation phase. This project then entered the maintenance and operation phase, with its on-call service (7 days, 24 hours) as an important part of the magnet operations.

The unit was also instrumental in developing control systems for external projects such as T2K, TOTEM, ECAL, ALFA and CAST; and also participating in the definition of projects such as Aegis and ArDM.

The FSU used for installation of these control systems was in addition engaged as a general support for experiments.

Magnetic field measurements

The group prepared the gear and helped in the measurements of two magnets in 2009.

The AMS super conducting magnet was mapped with a special gear carrying 15 sensors calibrated in 3D. This magnet was designed for the AMS experiment to search for exotic matter to be launched to the International Space Station.

The old UA1 magnet, now used at J-PARC, Japan in the neutrino oscillation experiment T2K, was measured with a special bench using pneumatic propulsion. It carried 89 3D calibrated B-sensors.

A start has been made to upgrade the 3D-calibrator for B-sensors. The electronics and mechanics will be modernized and the control software improved. The device will move from the MNP24 (1.5 T) to the PT7 (2.5T) magnet.
B-sensors and read-out electronics can now be produced by CERN. A batch of 200 B-sensors was produced and tested, 95 of them were used in the T2K mapping. 100 CAN interfaces, to be mounted on the back of the B-sensor, were built. 40 B-sensors were calibrated and delivered with CAN-interface to CMS. A new relay station with CAN interface was designed. Such a station is capable to read-out 4 chains of 32 B-sensors each.

Many users have visited the magnetic facility area to test the influence of a magnetic field on sensors, ventilators, vacuum valves, TL-tubes, etc. An upgrade of the cooling water supply was made; a high current switch was build for fast switching between magnets. The Danfysik power supply of the Varian calibration magnet was upgraded from SYS-8000 to SYS-8500.

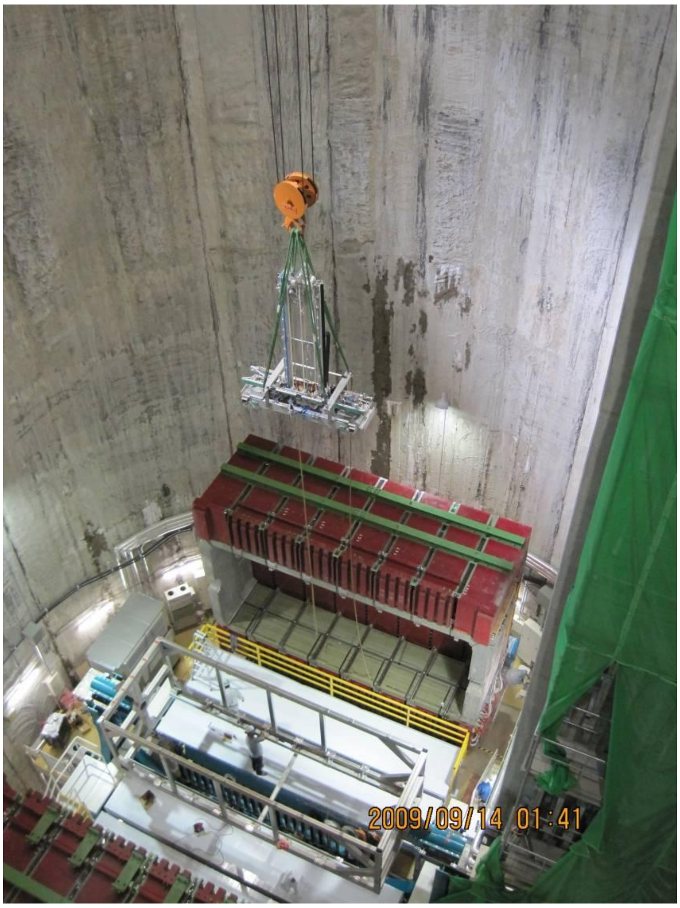

Figure 11: The mapping gear is removed from the UA1 magnet of the T2K experiment at J-PARC, Tokai, Japan.

Cooling systems for Experiments

The team gave support for all the cooling systems that serve the ATLAS experiment and participated in the consolidation of the CMS TK cooling plant.

The first half of 2009 saw the preparation and organization of the Detector Cooling Project (DCP) CERN wide and the set-up of the new cooling project within PH. The R&D plan for cooling and thermal management activities in PH/DT ("WP 11") was endorsed by PH management on 4 Jun 2009 and by DCP on 17 Jun 2009.

Three lines of R&D have been launched in the second half of the year and preliminary results have been presented:

- CO_2 cooling for detector upgrades (mainly targeting ATLAS and CMS);
- Micro-channel cooling for enhanced local thermal management (with the specific application of the NA62 GTK in sight);
- A new generation of relative humidity sensors based on optical fibre with submission of a Marie Curie Training Network proposal.

Mechanical workshops

The DT group has 8 mechanical workshops of which 3 are dedicated to support DT service activities like thin films and gas systems. The 5 other workshops include point 1 and 2 workshops and general purpose workshops for e.g. production of prototypes, complex assemblies, and quick fixes during detector assembly phases. These workshops provide work-space and tools also for project members of visiting teams. In 2009 the main investments were made to improve safety and working conditions, like workshop ventilation and evacuation of welding fumes and dust.

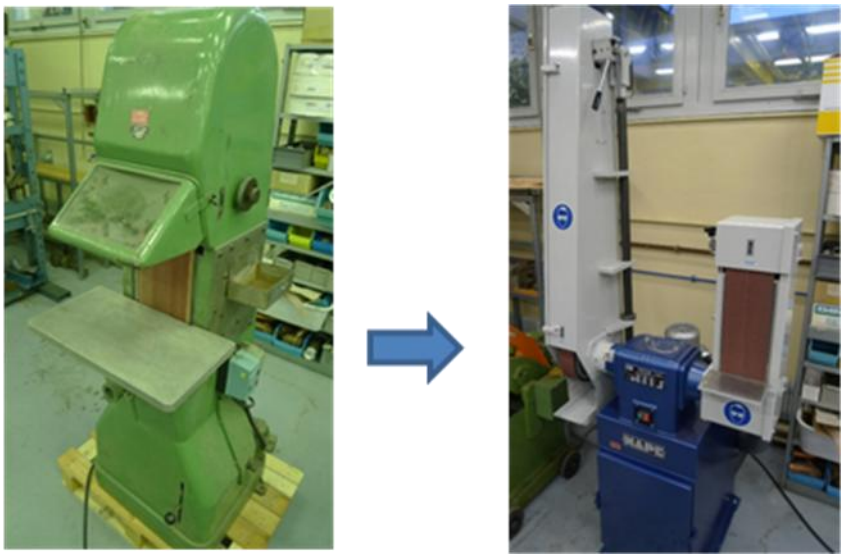

Figure 12 : An old sandpaper grinding machine is replaced by a new one with better ergonomy and integrated dust removal

Research and Development

The major part of the R&D work within the PH-DT group is funded through the 'White Paper' scheme and described in a separate chapter of the PH Annual Report. Below we describe two small activities which do not fall in this category.

Photodetector developments

The work on the X-HPD has been essentially suspended, following the declaration by PHOTONIS of the definitive end of their photomultiplier activity. A small feasibility study, supported by Hamamatsu Photonics, addressed the possibility of using Geiger mode APDs (Hamamatsu MPPC detectors) as anode of such an X-HPD which would bring advantages such as lower operational voltage and improved timing. The results show that G-APDs can be used to efficiently detect low energy (~10 keV) photoelectrons. An article has been submitted for publication in NIM A.

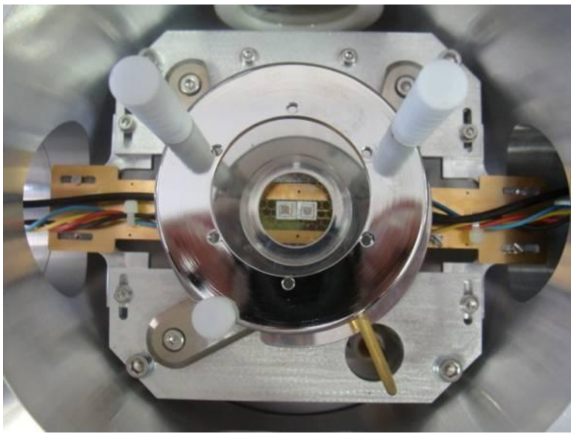

Figure 13 : Test set-up for the proof of principle of G-APDs as photoelectron detector.

AX-PET

The AX-PET collaboration (9 member institutes from Europe and US) made good progress in the demonstration of a novel PET camera principle, based on a matrix of long axially oriented crystals interleaved with plastic wavelength shifting strips for the reconstruction of the longitudinal coordinate. Two camera modules were constructed and fully tested with point sources. The performance agrees well with analytical calculations and detailed Monte-Carlo models. The work was presented at several conferences and led to numerous publications. It also received attention at the Physic for Health Workshop at CERN (Feb 2010, Best Poster Award, Special talk in plenary). Phantom measurements at the ETH Zurich and efforts for a possible commercialization through Finnish institutes and industry are in preparation. The main contributions of the DT group are the mechanical design and assembly as well as the overall-coordination of the activity.

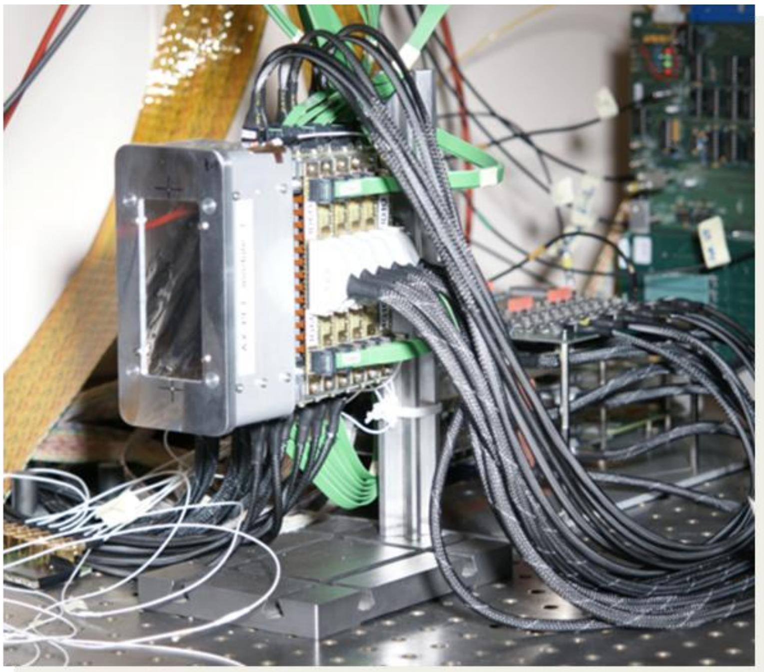

Figure 14 : An AX-PET camera module, fully cabled for characterization tests

Laser scanning

Tests of laser scanning methods and devices have continued in 2009 together with the survey group. Several meetings were held with outside experts and firms to evaluate 3D acquisition hardware. The results of the previous year scans in Atlas for the Inner Detector are being processed into 3D CAD models to assist with studies of future interventions for IBL project and SLHC upgrade.

Low mass opto-coupling

Investigations have started for a low mass optocoupling connector in collaboration with the electronics group at CERN.

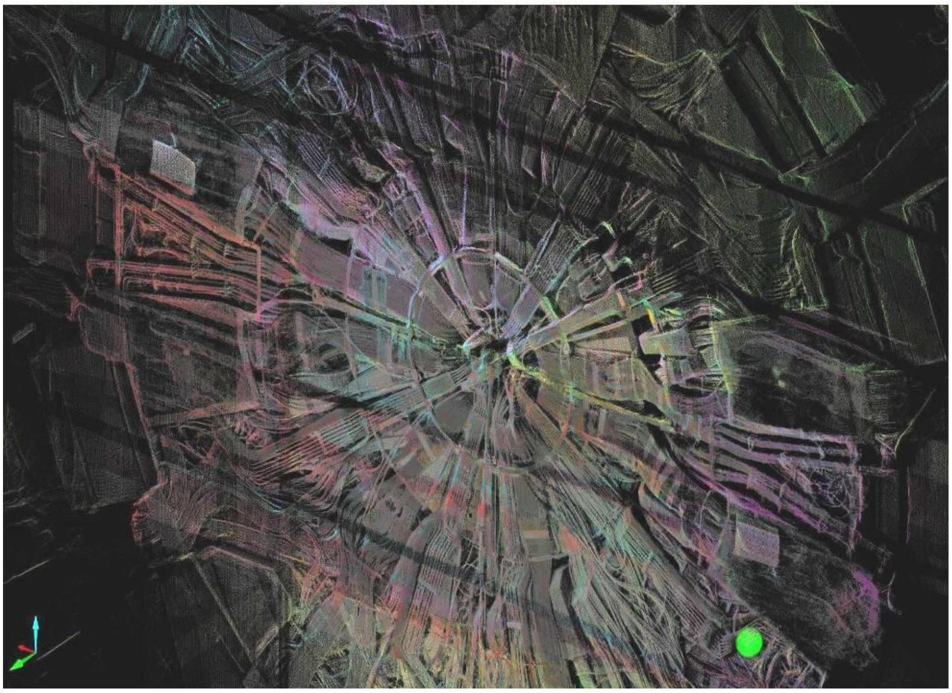

Figure 15 : CAD 3D model, produced by a LASER scan. The image shows the Atlas Inner Detector services (on the cryostat flange).

Other activities

MC-PAD

The funding of the Marie Curie Initial Training Network (ITN) MC-PAD, which was approved at the end of 2007, was negotiated with the European Commission. 22 positions with a total funding volume of close to 4.7 M EUR were granted. In 2009, the network filled 20 of its positions and started training and research activities. A first network training event (3 days) was held in Cracow, focused on readout electronics, including practical lab exercises. A second event is planned for January 2010 in Hamburg, addressing simulation with Geant4 and data analysis with ROOT. 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 and ILL) carried out at CERN first EIRO School on Instrumentation ESI 2009. With a total of 65 registered students and 34 lecturers, essentially all but one from the EIRO organizations, the School greatly fulfilled the expectations. Several DT physicists and engineers contributed as lecturers and a member of the group was in charge of the overall organization of the event. Feedback from the students on contents and organization was excellent and the School was accepted by the DG assembly meeting for implementation as a regular biennial event (with changing location and highlight topics). At the end of 2009, 6 EIRO organizations prepared a Marie Curie ITN proposal, targeting training of your young Researchers in the field of instrumentation. If approved, it would bring to the group 4 fully financed PhD positions (12 man years).

Representation in CERN working groups/committees

Interaction with CERN engineering activities

The change of CERN's main CAD system from Euclid to Catia-SmarTeam required in the years 2008-2009 major investments in CAD data migration, development of new work methodologies and training. Several members of the Project Office (PO) staff made significant contributions in these tasks. In addition PO staff had key roles in several PH- and CERN-wide engineering committees and working groups, like Computer-Aided Engineering Committee (CAEC), Groupe d'Utilisateurs Catia-SmarTeam (GUCS), CAD Use in Experiments (CADEX), and Computational Structural Analysis Committee (CoSAC).

Workplaces for Radioactive equipment

The DT group represented PH department in a working group reviewing the needs at CERN for future workplaces permitting intervention on and repair of radioactive equipment. Recommendations were made for such future workplaces.

Selection of publications involving DT members

- J. Mekki, L. Dusseau, M. Glaser, S. Guatelli, M. Moll, M. G. Pia, F. Ravotti, Packaging effects on RadFET sensors for High Energy Physics Experiments, IEEE Transactions on Nuclear Science Vol.56, No.4, August 2009, 2061-2069
- J. Duplissy et al., Results from the CERN pilot CLOUD experiment, Atmospheric Chemistry and Physics (ACP) Discussions, 9, 18235–18270, 2 September 2009
- A. Braem et al., AX-PET: A novel PET detector concept with full 3D reconstruction Nucl. Instr. Meth. A 610, (2009) 192-195
- M. Adinolfi, Performance of the LHCb RICH photo-detectors and readout in a system test using charged particles from a 25 ns-structured beam, Nucl. Instr. Meth. A 603, (2009) 287-293
- M.G. Bagliesi et al., The TOTEM T2 telescope based on triple-GEM chambers, Nucl. Instr. Meth., In Press, Corrected Proof, Available online 9 July 2009
- M. Alfonsi et al., Activity of CERN and LNF groups on large area GEM detectors, Nucl. Instr. Meth., In Press, Corrected Proof, Available online 2 July 2009
- A. Agocs et al., Very high momentum particle identification in ALICE at the LHC, Nucl. Instr. Meth., In Press, Corrected Proof, Available online 20 September 2009