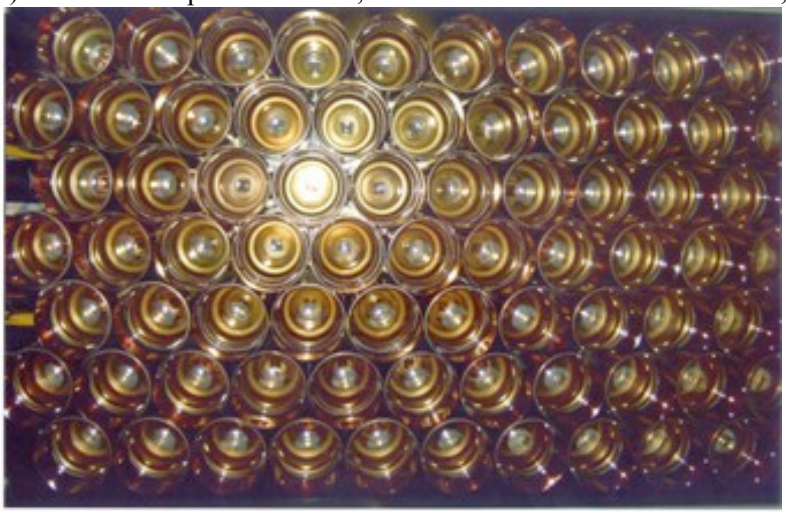
DT2 – Annual Report 2007

Detector Technologies group 2

The mandate of the DT2 group comprises development, construction, operation and maintenance of particle detectors. Its main competence and expertise are in the fields of precision mechanics, gas detectors, silicon detectors, scintillators, photon detectors and detector integration. The group is involved in the construction of all 5 LHC experiments and is providing a number of services which are accessible to all CERN users.
In 2007 the focus of the group's activities was mainly on completing construction, integration and finally installation of detector components. The group currently has 30 staff and comprises 4 sections. Many activities are being performed across section boundaries (see below).
Focused R&D projects in a few strategic areas are essential to develop the key technologies for future experiments. The group participated in the definition of the PH R&D work packages and will be involved in 4 of them. The group organized a workshop with more than 100 participants on micro pattern gas detectors as kick-off for a R&D collaboration in analogy to the well established RD50 collaboration.
The group initiated a proposal for a FP7 Marie-Curie training network on particle detectors involving several partner institutes. The proposal, which will be coordinated by CERN, was approved with an excellent ranking. Recruitment of trainees (in total 22) is expected to start in late summer 2008.

I. DT2-CI Construction and Integration

The section focuses on detector construction and integration work for the LHCb experiment. A senior technician of the group is in charge of the installation team in the cavern. DT2-CI contributes to the following activities:
Production of Pixel HPDs and participation in the LHCb RICH project: The series production and testing of all 550 tubes (including 66 spare tubes) has been completed in 2007, in close collaboration with PH-ED, the Dutch company DEP and the testing centers in Glasgow and Edinburgh. All HPDs are of excellent quality and yield. The commissioning of the RICH 2 detector, for which the installation of the HPD columns took place already in 2006, is very advanced. The integration of the HPDs on the RICH 1 columns, housing also the HV- and LV-systems and the Level 0 electronics has been completed during 2007. The mirrors for the RICH 1 detector have been coated and aligned, and also the installation of the other elements of RICH 1 is progressing.



Assembled HPD columns for LHCb RICH 1.

LHCb calorimeters: The group has provided technical support for the installation of the cable chains for the Calorimeters, in particular for the Preshower/Scintillating Pad detectors (PS/SPD) in LHCb. In addition substantial support has been provided for the finalization and commissioning of the moving- and cooling-systems for the PS/SPD detectors.
LHCb Velo: The assembly of the silicon sensor modules for the two detector halves of the LHCb Velo has been completed during the past year. The group was instrumental in overcoming several problems encountered during the integration of the detector. Several improvements on the mechanics had to be implemented to achieve the required assembly precision and reliability of the operation. After a final

alignment of the modules in the metrology service and thorough tests in the lab, the two detector halves have been successfully transported and installed in the LHCb experiment.
LHCb Muon system: The group has completed the conditioning and testing of all Muon chambers under CERN responsibility. The gain uniformity and high rate behavior of these chambers, which will instrument the parts of LHCb Muon system exposed to the largest particle flux, are excellent. The group also coordinated the installation and integration of the muon system. The chambers for stations M2-M5 are installed and aligned, and the commissioning of the detector, including its gas- and HV-systems, is advancing rapidly. Advice has also been provided for the integration of station M1, of which the installation is progressing.

II. DT2-EC Engineering and Construction

The EC section works in the following 4 projects of the CMS experiment: ECAL End-Caps, Preshower, Tracker, and CMS General Integration. Together with ST section, the EC section works also on the TOTEM experiment, located at Point 5 next to CMS.
DT2 ensures the functioning of the ECAL End-Cap assembly site 'the Crystal Palace' at CERN, and participated in the set up and commissioning of the final assembly line in building 867. From mid-2007 a DT2 physicist started as the co-ordinator of the ECAL End-Cap assembly at CERN. Super crystal installation on the first two of the four End-Cap "DEEs" was completed. The electronics mounting in combination with the complex cooling block circuits started immediately after. Furthermore, one of the DEE's was equipped with 20 super crystals and installed in the H4 beam-line in autumn 2007 to perform integral tests. The beam setup consisted of a rotating and pivoting support table that was modified to suit the scanning of the ECAL End-Cap geometry.
DT2 has the responsibility of designing and producing the main mechanical components of the CMS Preshower detector. In 2007 engineers and technicians from both DT2 and DT1 groups contributed to this project. Preshower absorber plate production got to full swing in 2007. These D-shape absorbers are made of lead core plates with facing plates and closing edges in aluminum. Handling tools and gluing methods were developed and put in use. Heating foils were glued to the paraffin "windows" of the Preshower, and two more cooling screens were produced to replace the ones that had brazing quality problems. A test was setup at end of 2007 to measure and ensure adequate coolant flow in the cooling screens. The design of the outer drum structures was finalized and these components were launched into production after a difficult tendering exercise. The group's members supervised design and production of various components of the detector's inner services, such as the galvanic feedthroughs and the spliced optofibres. The group also maintained its narrow involvement in the services' integration.
After successful completion of the Tracker Outer Barrel (TOB), the DT2 had responsibilities in 2007 in the CMS Tracker assembly and service installation. The group provided tooling and supervision for the installation and positioning of the other Tracker sub-detectors into the Tracker Support Tube. An existing full scale mock-up of a Tracker service channel was updated to the final geometry and used for training Tracker installation teams. In collaboration with the PH/CMT and Helsinki groups DT2 developed, prototyped and produced copper cooling circuits for these service channels, to allow a newly requested warm temperature operation of the Tracker during its first low-luminosity years. DT2 supervised the design and production of 500 cooling pipes, 4 meters long and all of different geometries, needed at CMS in early 2008. An engineer and a technician from DT2 participated at the end of 2007 in the final insertion and alignment of the Tracker inside CMS.
An engineer from DT2 acts as the CMS Detector Services Co-ordinator, and is involved with several areas of engineering and technical co-ordination for the experiment. Specific responsibilities were the procurement of all cable chains required for the experiment, and supervision of rack-space use at Point 5.

Short-duration help was provided by a DT2 engineer to the PS215-CLOUD experiment on the editing of EU Design Study and Marie Curie applications. The Marie Curie application, co-ordinated by Univ. of Frankfurt, was approved by EU for funding due to start in 2008.

III. DT2-SD Solid State Detector Support and R&D

This section provides general support to all CERN experiments for solid state detector activities and radiation hardness tests. The main installations are the PH Department Silicon Facility (DSF) with the Bond Lab, the irradiation facilities in the PS East Hall and the Gamma Irradiation Facility (GIF). Some R&D activity is maintained in the fields of radiation sensors (RADMON) and solid state detectors (RD50).

The main activity throughout 2007 in the Bond Lab was the preparation of the production of 4500 CMS Preshower modules. After extensive sensor quality testing and module prototyping work the production of modules started in the last quarter of the year and reached almost 1000 modules at the end of 2007. Further important activities were the production of Alice Pixel modules, MEDIPIX devices, Beam Condition Monitors for ALICE, ATLAS and CMS and prototyping work for the TOTEM project. Various smaller bond jobs were performed for the ESE-group, several CERN-TT projects, RD39, RD50, ATLAS Pixel, RADMON and others including several urgent repairs for test-beam activities. Following some technical problems the number of bond machines had to be reduced from three to two, while the remaining machines could be refurbished and upgraded. The DSF clean room space and infrastructure maintained by DT2-SD served for the assembly of several LHC detectors (ALICE Pixel, CMS Preshower, LHCb Tracker, LHCb Velo, LHCb RICH) and MEDIPIX devices. In view of the LHC startup the facility was reaching its limit in terms of capacity and additional temporary clean room space outside the main facility had to be constructed.

The PS irradiation facilities experienced a strong increase in irradiation requests and reached a limit in their throughput leading to the rejection of some irradiation requests. In 135 days of beam time about 1500 objects were irradiated and about 500 dosimetry measurements were performed. The main clients were ATLAS, CMS, RD50, RD39 and RD42 testing mainly silicon sensors and detector systems for the LHC upgrade, but also optical link systems, calorimeter crystals, electronic components, dosimeters, radiation monitors and other types of components and materials. In July 2007 DT2-SD took over the responsibility for the Gamma Irradiation Facility (GIF) in bldg. 190 from the ESE group. A smooth transition in operation and maintenance was assured. Main facility users in the second half of 2007 were colleagues from the LHCb Muon and LHC Beam Loss Monitor projects.

In the framework of the RADMON project radiation sensors were provided to the LHC Experiments (ALICE, ATLAS, LHCb and TOTEM) and a low level of R&D focusing on low cost commercial and custom made silicon pin diodes was maintained.

In the framework of the RD50 project radiation tolerance studies on detectors based on newly developed silicon materials were continued with the main focus on p-type Magnetic Czochralski Silicon and p-type epitaxial Silicon layers. The overall work of the RD50 collaboration (50 Institutes, 260 members) was supported and steered by providing a co-spokesperson, administrative support, the budget holder and the co-ordination of several RD50 common projects. Along with the research work the Solid State Detector Laboratory in bldg. 28 was maintained and made accessible for various CERN users. In collaboration with an outside institute a new detector test system based on the Transient Charge Technique is under development.

IV. DT2-ST SPECIAL TECHNOLOGIES

The section regroups a number of *special technologies* such as functional thin films, gas detectors, scintillators, as well as glass and ceramic machining. The main activities in 2007 were:

For the TOTEM T2 detector, the component production for the GEM-chambers arrived at completion and work on the detector integration (readout cards) and installation in the CMS HF continued. The design for the integration of the Silicon detectors of the Roman Pot Detectors was finalized and all components and tooling procured or produced in-house. The required alignment precision was demonstrated and thermal cycling tests were performed. The work has been performed jointly with the EC section.

The ATLAS ALFA project team aimed at fabricating a full RP detector module while at the same time transferring technologies and responsibilities from CERN to the collaboration partners. Difficulties in the coating process of fibres encountered by an external team delayed the schedule. The group was involved in the reception and optimization of the Roman Pot mechanics and in a successful test beam at DESY dedicated to the ALFA trigger detectors.

In addition to the substantial involvement in the ATLAS ALFA project, the activities of the Thin Film and Glass (TFG) lab comprised many smaller thin film projects such as mirrors coatings, CsI on thick GEM for

Compass, CsI on a Gas Pixel Detector, etc. The CNC milling machined was fully commissioned for glass and ceramics machining.
In parallel to the TOTEM related work described above, the activities of the gas detector team in their new labs in hall 154 focused on the development of technologies for very large GEM detectors and the use of so-called thick GEMs in photosensitive devices (using CsI films as photoconverter). The team is playing a central role in the PH R&D WP 5 and the RD51 collaboration.
In collaboration with the company PHOTONIS, a further prototype of the so-called X-HPD was built and successfully tested in view of the application of this potentially cost-effective technology for large area photon detection in underwater neutrino experiments.

Selected publications with major contributions of DT2 members

- The COMPASS experiment at CERN, Nucl. Instr. Meth **A 577**, (2007), 455-518
- Glass-coated beryllium mirrors for the LHCb RICH1 detector, Nucl. Instr. Meth A **570**, (2007), 565-572
- Hadron beam test of a scintillating fibre tracker system for elastic scattering and luminosity measurement in ATLAS. *Journal of Instrumentation 2 (2007) P07004*
- Depth of interaction determination in GEM-based multi-layer PET detectors, Nucl. Instr. Meth A **582**, (2007), 693-695
- Design and prototype studies of the TOTEM Roman pot detectors, Nucl. Instr. Meth A **581**, (2007), 499-503
- The X-HPD: Development of a large spherical hybrid photodetector, Nucl. Instr. Meth A **581**, Issues (2007), 469-472
- CCE measurements and annealing studies on proton-irradiated p-type MCz silicon diodes, Nucl. Instr. Meth A **583**, Issue 1, (2007), 64-70