


## Editorial

Dear Friends

The technical shutdown of the LHC allowed much consolidation of the accelerator and of CMS. The activity surrounding both is now virtually complete and in this edition of the CMS Times Martin Gastal takes us through the final CMS-related efforts taken to ensure our detector is ready for real physics data taking. Indeed LHC operations have have begun again, with the first "splashes" seen in CMS this past weekend, as mentioned in the e-commentary: http://cms.web.cern.ch/cms/News/e-commentary/cms-e-commentary10.htm

In fact the CMS detector is in excellent shape, with many things that were planned to occur after several months of running already achieved. For example, the alignment of the silicon sensors that form the Tracker has been performed to an excellent precision, as reported in our "Alignment of a Giant" feature story.

In the run-up to more collisions and, potentially, early new physics, LHC-related stories are becoming ever more popular in the world's media. Our media section summarizes some of these stories.

With kind regards

The CMS Times Team

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## People

### INFN & University of Pavia (Italy) in CMS

Members of CMS group from INFN & the University of Pavia. From left to right: C. Riccardi, S.P.Ratti, U.Berzano, P.Vitulo, C.Viviani, P.Baesso, D.Pagano, A.Vicini. Not on the photo: P.Torre and G.Belli.

The Pavia group (whose members belong to INFN & University of Pavia) has been involved in CMS since 1995, participating from the very beginning to the development of the bakelite Resistive Plate Chamber (RPC) detector. Its experience in High Energy Physics and in particular in the RPC domain benefits from the previous participation to E771 E687 and E831 experiments at Fermilab where the RPCs were successfully used.

Starting from scratch, the Pavia group has been

## CMS Outreach, Visits and Media

**From *National Geographic* (22.02.2010):**

***LHC Restarts This Week-Half Power But Full of Potential***

The Large Hadron Collider (LHC) is slated to be reawakened Thursday, at the earliest, LHC directors say. The reboot comes after a run at the highest energies yet for any particle accelerator—or atom smasher—and a scheduled winter break...

*Read more*

**From *FOXNews* (22.02.2010):**

***Scientists to Restart World's Most Powerful Atom Smasher***

Scientists at the European Organization for Nuclear Research (CERN) are restarting the world's most powerful atom-smasher over the next few days, continuing the quest for the mysterious Higgs Boson and other answers to the universe's mysteries...

*Read more*

**From *JITEC* (25.02.2010):**

***Une nouvelle annee prometteuse pour le LHC !***

Depuis le 20 novembre, date à laquelle les premiers faisceaux ont de nouveau circulé dans l'accélérateur LHC, les annonces du CERN se sont succédées, toutes porteuses de bonnes nouvelles...

*Read more*

**From *The Associated Press* (28.02.2010):**

***Atom smasher restarts to prepare for new science***

The European Organization for Nuclear Research, or CERN, sent low energy beams of protons in both directions around the 27-kilometer (17-mile) tunnel housing the Large Hadron Collider under the Swiss-French border at Geneva...

*Read more*

**From *Times of Malta* (28.02.2010):**

***CERN atom smasher restarts***

Scientists have restarted the world's most powerful atom-smasher overnight, the European Organisation for Nuclear Research (CERN) said, as they launch a new bid to uncover the secrets of the universe...

*Read more*

## News from Point 5

The crash program started on 16 December 2009 is now close to completion. It has been a very exciting exercise from which much can be learnt. Several achievements should be highlighted. The initial goal of replacing the bushings on the YE+/-1 cooling circuits has been fully met. In addition, the bushings on all End Cap elements have also been changed. This increase in the scope of the crash program was made possible by the faster than expected opening and closing of the Enc Caps and by making use of the contingency built in the plan. Having all the bushings replaced on both End Caps has dramatically reduced the risks of having a leak similar to the ones spotted last year. The outstanding work of all actors involved should be praised.

The TOTEM T1 Truss installation (by Marco Bozzo)

While the work of our long term plumbing industrial partner ZEC has once more been outstanding, another team of local staff has been successfully involved in the replacement of the bushings. This was very important for CMS since increasing the number of sources for critical resources will allow faster and more flexible reaction to future potential incidents.

The TOTEM T1 Truss was installed on the +Z end of CMS. This operation did put some stress on the schedule of the closure of the detector but will have long term benefits. With the Truss in place, the installation of T1 could be done without having to open the +Z en d cap. As a result, a short access to the cavern could prove to be enough to launch the installation of the T1 responsible for the entire (i.e. barrel and forward) production and quality control of the bakelite RPC electrodes whose bulk resistivity was measured through an automatic tool properly projected and built at the INFN Pavia site. Other experiments (like Argo and Phenix) that make use of RPCs have also benefited from this tool. During the phase of detector's assembling the Group projected and developed tools for the quality control of the front-end chips and boards.

Later on the Pavia Lab became one of the test sites (along with Bari and Sofia) of the assembled barrel detectors. The performance of all the first inner layer of the barrel RPCs (called RB1, 120 chambers out of 480) has been tested at the Pavia INFN Laboratory where a cosmic rays test stand was available. A particular mention has to be addressed to an early study that has been started by our Group: the effect on the RPC Bakelite electrodes of corrosive compounds that might be produced inside the gas gap during the operation. After the phase of RPC commissioning and installation at CERN into which the group has been greatly involved, recently contributions are related to simulation and analysis of “exotica” and high mass resonances signals as well as participation to shifts, RPC database and RPC Gas Detector Control System development.

Davide Pagano, a PhD student from the University of Pavia

My name is **Davide Pagano** and I am a PhD student at the University of Pavia (Italy) since October 2006. Currently my activity is mainly related to the improvement of high-energy muons reconstruction and on the search for Z' resonances (predicted in many extensions of the Standard Model) decaying to muon pairs.

As well as this, I am also involved in the RPC group, where I manage the creation of the RPC conditioning objects and their copy from the online database to the offline one. Besides, during these years, I also had the possibility to work on other software items related to the RPC (validation, standalone reconstruction, etc…) and to do shifts during the data acquisitions.

Naturally, to stay at CERN gives me a great help to follow these jobs and I luckily have the possibility to spend a lot of my time there.

Beside to the work, the CERN is nicely placed: mountains and lake are very closed, allowing a lot of tourist activities, and Geneve (just few km away) offers a lot entertainment. So, it is not easy to get bored.

Watch the interview with Davide on You Tube:

Replacing the bushings, water is being drained by 2 ZEC workers and Dan Wenman, an engineer from PSL (by Richard Breedon)

This crash program was also the opportunity to demonstrate in practice how fast the detector can be safely opened and closed. The performance achieved will become a baseline for the future openings. Procedures used during these operations will benefit from what has been observed and will be optimized to include finer breakdown of the activities and responsibility matrix.

detector.

The pump down of the beam pipe was also very fast despite the breakdown of a turbo pumps. It did highlight some influence of the magnetic field on vacuum equipment, a difficulty that will have to be addressed in the coming months.

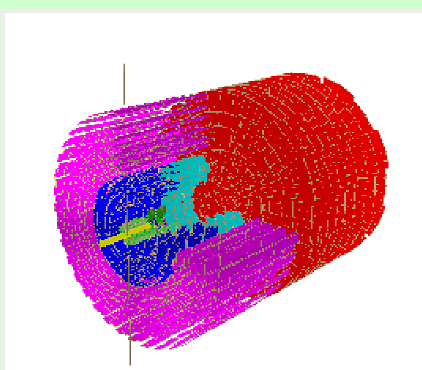
All together, the crash program by far exceeded the goals stated last year and the detector is in a very good state and ready for a long period of Physics data taking.

*Submitted by:*

*Martin Gastal*

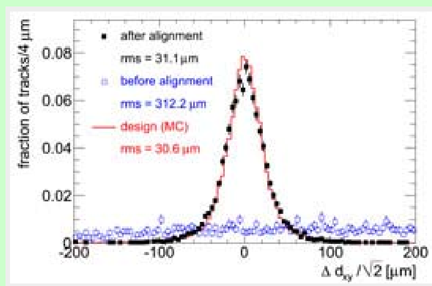
## Alignment of a Giant

At first sight there does not seem to be much in common between the CMS detector and the ancient pyramids of Egypt. The former is rather complex but relatively compact, whilst the largest of the latter is almost 10 times higher than CMS at nearly 150m tall and is made of "simple" stone blocks. But they do share one common factor: in order to achieve their goals the alignment of the individual pieces has to be extremely precise. Some of the 2.3 million stone blocks that form the Great Pyramid of Giza were made to a tolerance of a quarter of a millimeter, such that a razor blade cannot pass between them - an incredible feat of engineering more than 5000 years ago. Many of the components of CMS had to be placed in position to even better tolerances. The silicon tracking system alone comprises more than 75 million individual pixel or strip channels arranged in 16588 modules. To measure the passage of charged particles to the required precision of about a dozen of microns requires a knowledge of each individual channel position to a few microns (see CMS Times). But even today it is impossible to place the silicon modules inside CMS to this precision - a couple of hundred microns is the best we can do. Surveying techniques, used widely for the large structures of CMS, cannot improve matters significantly as the modules are hidden deep within the heart of CMS. Instead we have resorted to methods similar to those used for the analysis of the pyramids!



View of half (z<0) of the CMS silicon pixel and strip

Over the past three years the CMS collaboration conducted several large-scale data-taking exercises, with and without the magnetic field, above and below ground. Hundreds of millions of cosmic muons were recorded, of which several million passed through the Tracker and could be used for alignment purposes. The procedure required the alignment team to establish each individual module position with respect to the passing muons. The problem becomes complex for two reasons: firstly, there are about 100000 free parameters for module positions and rotations; secondly the muons do not follow perfectly straight paths (or perfect circles in a magnetic field) but are deflected (scattered) by material, resulting in even more degrees of freedom for the computations.




Impact parameter resolution of cosmic muon tracks passing near the nominal interaction region. Performance after alignment, before alignment, and design are compared

Nonetheless, the results of alignment analysis with cosmic rays exceeded most expectations. Prior to this procedure the alignment precision (from placement alone) was between 200 and 700 microns - already an amazing achievement. But after the use of the cosmic rays our knowledge of module position improved to 3-4 microns (for barrel modules in the bending plane as measured with respect to particle trajectories, and the endcaps are a little worse). This is equivalent to an improvement in the precision with which we can measure particles from about 150 microns to about 15 microns (for 100 GeV muons) such that the CMS Tracker performance was already very close to the design specification even before any collisions had occurred in the LHC!


## Links

- CMS in the media
- LHC
- ATLAS
- ALICE
- LHCb
- TOTEM
- CERN
- CERN Bulletin
- US LHC
- UK LHC
- LHC France

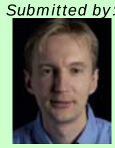
Tracker modules as measured in alignment procedure
(click on the image for animated view)

About 40 years ago Nobel Prize-winning physicist Luis Alvarez and his team used cosmic ray detectors to search for secret chambers in the pyramids. Even though no new chambers were found, it was a proof of principle that cosmic rays could be used as a kind of giant X-ray machine, locating hidden objects. Unlike conventional X-ray machines, there is no limit to the surface area that can be covered by cosmic rays; indeed every minute several hundred cosmic rays, mainly muons, pass through every person on the planet. As silicon sensors are designed to detect charged particles, such as muons, the use of cosmic rays for alignment analysis of silicon detectors is a natural thing to do, and has been used successfully for many years. However, the silicon tracker of the CMS experiment is about 100 times larger than any previous similar device and thus represented a huge challenge.

These results have been published in the first paper by the CMS Collaboration prior to LHC collisions (see preprint ). Certain challenges still remain, to utilize fully all alignment information, and are the focus of ongoing work.

The ancient pyramids of Egypt have, for millennia, hidden mysteries left by their creators. On the other hand, physicists at CMS hope to uncover some of the mysteries of Nature. While the careful alignment of the pyramids was designed to carry a message, the precise alignment of the CMS detector components was a crucial step in achieving its design goals, paving the way to discoveries.

*Submitted by:*



*Andrei Gritsan*

**Web-cam latest images** (click picture to enlarge)