STATUS OF THE LHC EXPERIMENTS.

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Abstract

A brief description of the status of the preparation of the large LHC experiments is given. The construction of the four experiments is now so advanced that they will be ready to take data in spring 2007, even if some of the detectors have to be staged. The construction of the magnets is well advanced. It is foreseen to have them installed before the end of 2004, including the big eight coils of the ATLAS barrel toroid

I. STATUS OF THE MAGNETS

There are 8 new magnets in the LHC experiments, 5 of which are super-conductive. They all are in a very advanced stage of construction. The coils and the steel plates for the yoke of the LHCb dipole magnet have been produced and delivered to CERN. Their installation in the LHCb experimental hall has started with the magnet support structures being assembled. This project is well on schedule.
The dipolar magnet used by ALICE to measure the momentum of the muon produced in the forward direction is also in a very good state of the construction. The two coils are at CERN (Fig.1). The iron steel plates, already built and assembled at Dubna, have not yet arrived, but they will be shipped soon.

Fig.1. ALICE- dipole Coil handling

Furthermore the ALICE central solenoid, the old magnet of the L3 experiment at LEP, has been modified and is now ready (Fig.2).

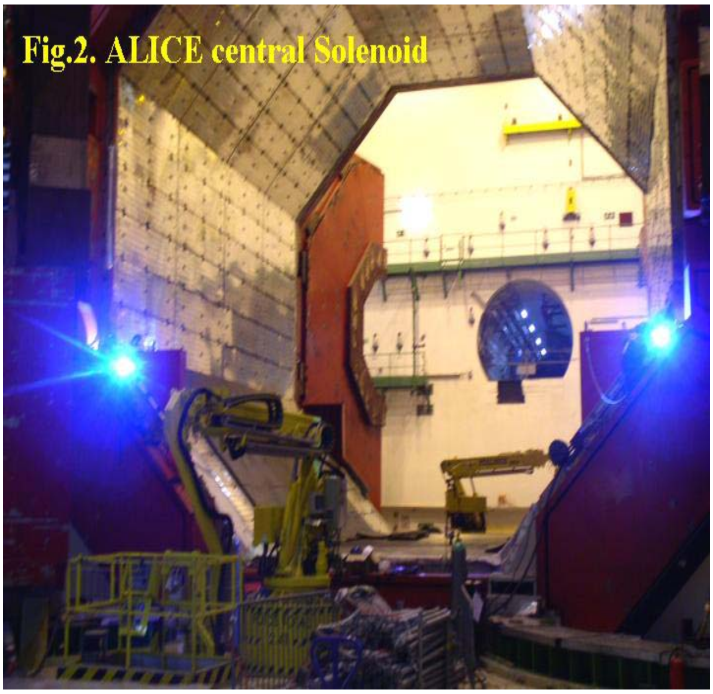
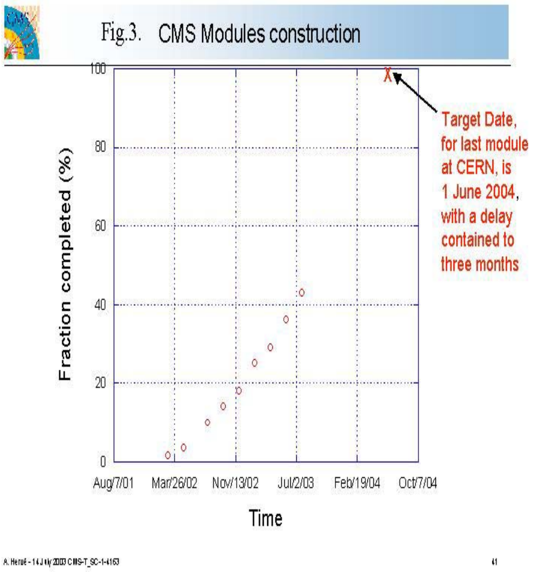


Fig.2. ALICE central Solenoid

The assembly of the five rings of the return iron yoke of the CMS magnet is well underway on the surface at Point 5. Muon chambers are now being installed in the iron.
The first of the five coils of the CMS solenoid has been impregnated in ANSALDO. Because of problems during the impregnation, a non-uniform impregnation of the conductor has resulted. It will now be necessary to mechanically remove the extra resin, an operation which, given the dimensions of the object, is far from simple, and might cause further delays. The construction of the five coils is nevertheless well underway. It is estimated that 50% of the work has been done (Fig.3). There is still a good probability that the five modules will be completed by June 2004.



The ATLAS experiment has four large super-conducting magnets: the Central Solenoid (CS), the Barrel Toroid (BT) and the two End Cap Toroids (ECT). The coil of the Central Solenoid, turret and chimney were delivered to CERN in 2001.

Good progress is also reported on the components of the Barrel magnet, including the integration of the coil in its casing, the vacuum vessel, the integration into the cryostat, and the cryogenic systems. The eight coils have been mounted in their casings (Fig.4).

Fig.4-ATLAS barrel coils

Some concerns remain about the delay in the delivery of the thermal shields. This has resulted a delay to the project of two months. The first coil should be tested in the cold in February 2004. The installation of the first coil will begin in March 2004. The eight Barrel Toroid coils are expected to be all installed in November 2004.

The installation of the ATLAS barrel magnet is one of the experiment's major challenges; it will determine the overall installation schedule. Good progress is also reported on the construction of the conductor, the vacuum vessel and the cold mass of the End Cap Toroids.

The End Cap Toroids schedule is no longer critical. The final assembly is expected to be on time.

The general picture is that by the end of the year 2004 all the magnets should be assembled, two and half years before the first pilot run in the accelerator.

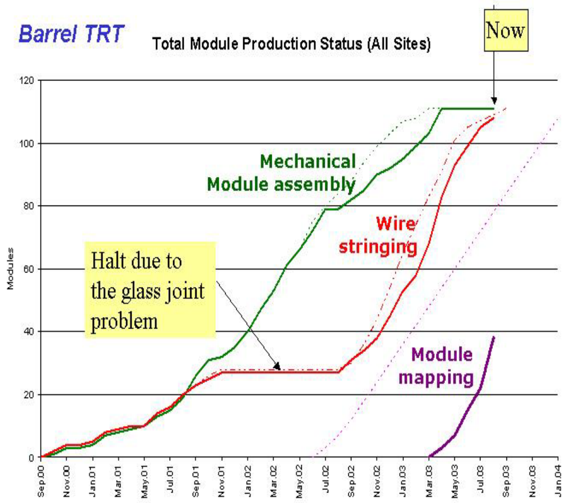
II. STATUS OF THE DETECTORS

A. *ATLAS*

The construction of the majority of the ATLAS sub-detectors, with their read-out electronics, is well under way. The installation of the technical infrastructure in the underground cavern is in progress, and the installation of the ATLAS detectors will start soon, in parallel with the installation of the magnets.

The construction of the Inner Detectors is advancing well (Fig.5). The R&D work for the pixel detector is coming to an end and the construction of the first final pixel modules will start soon. There have been some delays in the construction of the Transition Radiation Tracker (Endcap A) and in the Silicon Tracker (Endcap A). These end cap systems have used up the contingency in their installation schedule.

Fig.5- Status of the construction of the ATLAS TRT detector.



The production of the silicon tracker barrel modules is proceeding well, but it must accelerate in order to meet the planned start of the installation. The procurement of the total number of wafers for the front-end electronics of the Silicon Tracker (SCT) and the Transition Radiation Tracker remains a concern due to the use of DMILL electronics.

The construction and integration of the LAr calorimeter modules (the "accordeòn"), and their cryostats, are progressing well. All the barrel modules are inserted in the cryostat, and one of the forward end cap calorimeter systems has been inserted in the forward cryostat.

The construction of the hadronic Tile Calorimeter is also very well advanced. One of the extended barrel tile calorimeter has been fully assembled. Although the full calorimeter is now ready to begin the installation in the cavern, the read-out electronics is still under construction, but no major delay is expected.

Good progress has also been obtained also on the muon systems. The expected number of Monitored Drift Tubes (Fig.6), Cathode Strip Chambers, Resistive Plate Chambers and Thin Gap Chambers, will be produced on time, in phase with the installation.

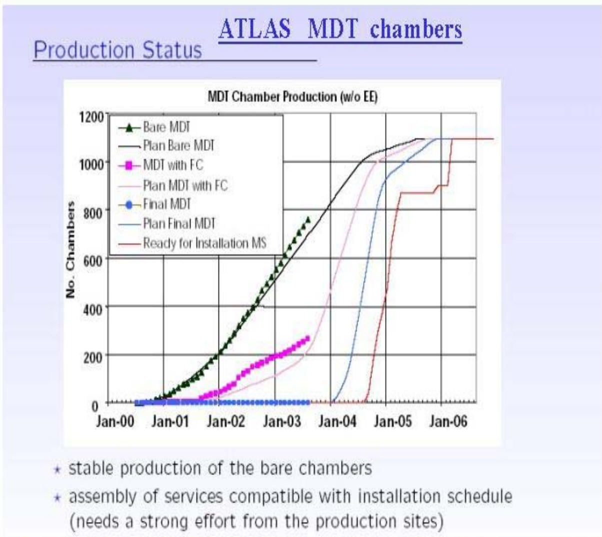


Fig.6- The ATLAS-MDT muon detectors. Status of the construction.

The major concern remains with the sustained rate of production of the completed chambers, due to the challenging schedule and the complexity of the installation.

The installation and commissioning of ATLAS will be very difficult because of the large dimension of the magnets and the complexity of the detectors. It is nevertheless realistic to expect ATLAS to have an initial working detector ready for the start of LHC operation in April 2007, although detector installation can be foreseen beyond this date.

The staging plan consists of deferring the installation of some components of the Inner Detector, the Higher-level Trigger and the DAQ. Detector elements not installed by April 2007 will be staged.

Their successive installation during a long shutdown would complete ATLAS as it was presented in the original proposal.

The commissioning of the ATLAS detector, trigger and read-out electronics, is expected to begin in summer 2006 with cosmic rays (Fig.7).

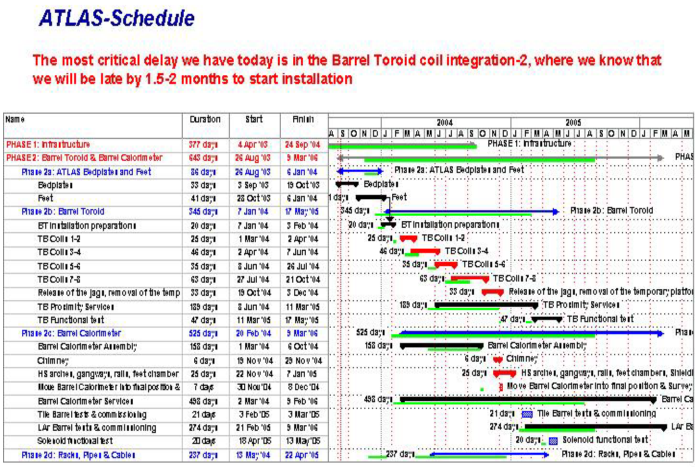


Fig.7- General schedule of the ATLAS collaboration.

B. CMS

The CMS Pixel Vertex Detector project is converging towards the final design, and with no critical items identified. The barrel module production has started and the first prototype modules are available. We reiterate that the pixel detector of CMS should be installed after the first pilot run, to protect it from possible radiation damage, when the first beams circulate in the accelerator.

The time construction of the Silicon Strip Tracking detector is very challenging. Care must be taken to ensure that all components are available on time (Fig.8) and that the logistics of moving them around the various production sites runs smoothly. The module production has started, providing "proof of principle" for the distributed production, however additional time is needed to estimate the series production rate.

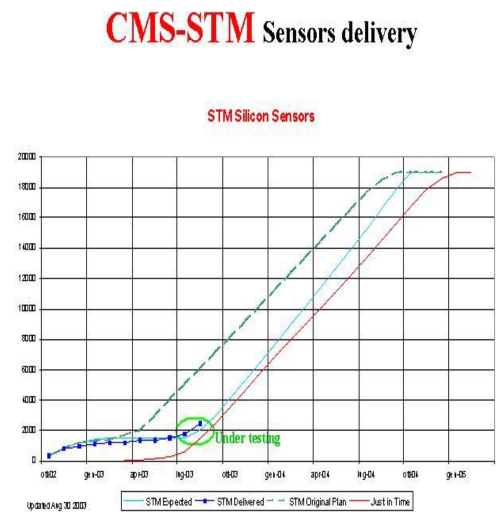


Fig.8- CMS silicon tracker.

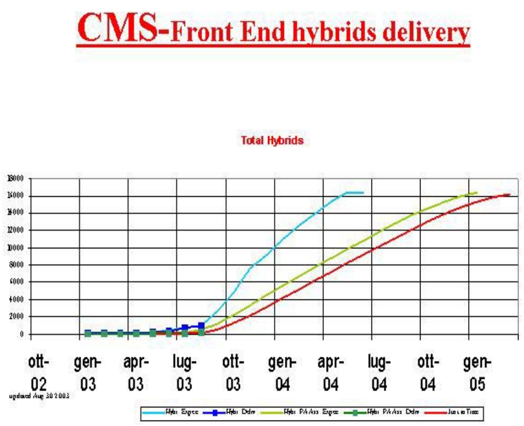


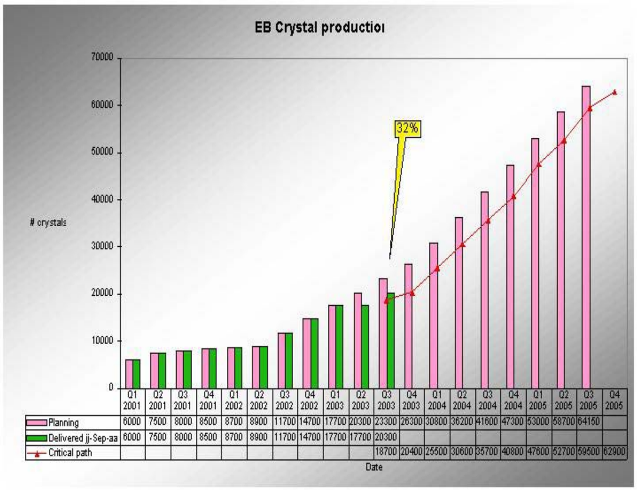
Fig.9- CMS tracker. Front end electronics.

After resolving problems related to quality control, the recent delivery of sensors was on schedule.

The construction rate of the read out front-end hybrids is increasing. It was reported recently that a front-end hybrid was damaged during module manipulation. Investigation showed that the lines near the connector are brittle and the bending of the flex could break the connectors. CMS is investigating, together with the industrial partners, the production of hybrids with stiffeners. Hence the series production of the hybrids has not yet started (Fig.9).

The 3-month contingency in the Silicon Strip Tracker schedule, before it is required for installation, has been used up.

The crystal production for the electromagnetic calorimeters, the ECAL Barrel (EB) and the two ECAL End-caps (EE), is on the critical path. The ramping-up of the crystal production has not progressed at the expected rate (Fig.10).



	Q1 2001	Q2 2001	Q3 2001	Q4 2001	Q1 2002	Q2 2002	Q3 2002	Q4 2002	Q1 2003	Q2 2003	Q3 2003	Q4 2003	Q1 2004	Q2 2004	Q3 2004	Q4 2004	Q1 2005	Q2 2005	Q3 2005	Q4 2005
Planning	6000	7500	8000	8500	8700	8900	11700	14700	17700	20300	23300	26300	30800	36200	41600	47300	53000	58700	64150	
Delivered jj-Sep-aa	6000	7500	8000	8500	8700	8900	11700	14700	17700	17700	20300									
Critical path											18700	20400	25500	30600	35700	40800	47600	52700	59500	62900

Fig.10- CMS ECAL. Crystal delivery.

As the overall ECAL schedule is dominated by the delivery of crystals, negotiations between CMS and the crystal supplier are ongoing in order to try to improve the delivery schedule. Scenarios, such as the insertion of a few ECAL Barrel Super-modules after the installation of the Tracker, and postponing one of the end cap detectors (End cap ECAL-) installation until after the LHC pilot run in 2007, are being studied. Excellent progress has recently been made concerning the construction of the ECAL electronics. The new technology and the new architecture have been successfully designed, built and tested.

Nevertheless, in order to calibrate as many modules as possible with an electron beam, during the 2004 test beam period, the final electronics must be produced this year. We consider this schedule to be extremely tight.

The present planning allows for only about 5 Super-modules to be calibrated in the beam in 2004.

The construct the ECAL on time will be challenging.

On the contrary the construction of the Hadron Calorimeter is very well advanced. The calorimeter is assembled (Fig.11).

Fig.11- CMS Hadron calorimeter.

The production of the muon Drift Tube (DT) chambers is well underway; very good progress is also reported on the construction of the Cathode Strip Chambers (CSCs) (Fig.12). The installation of the muon chambers for the forward arms has started.

Progress is also reported on the construction of the Resistive Plates Chambers (RPCs) (Fig.13). to be used to trigger on muons. The production of the chambers is in the mass production phase and, so far, adequate to meet the requirements for installation

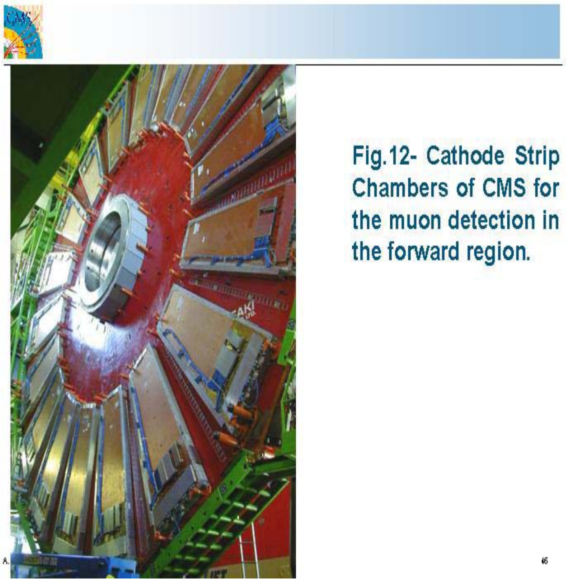


Fig.12- Cathode Strip Chambers of CMS for the muon detection in the forward region.

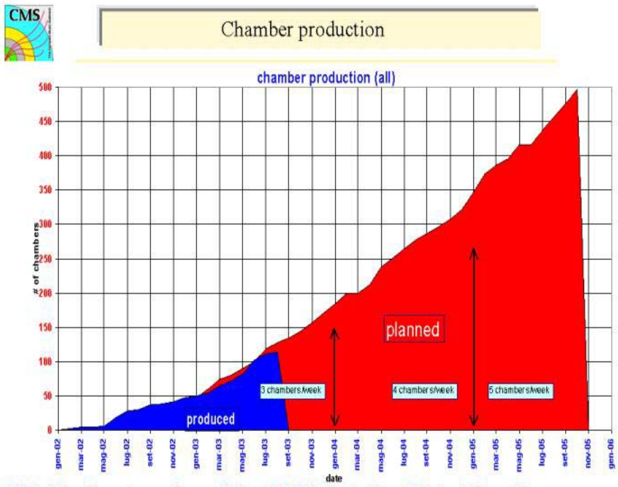


FIG.13- Construction of the CMS Resistive Plate Chambers.

The ageing tests of the RPCs at the Gamma Irradiation Facility (GIF) are continuing in order to test the final chambers with a closed loop gas system, as they will be used at the LHC.

The very complex system making up the LVL1 trigger is also advancing well but because of the later delivery of the underground cavern USC55, the time installation and commissioning of the trigger system is reduced and it is considered to be tight.

Good progress was also reported for the DAQ. The Front-end Read-out Link final prototypes have been tested, and their pre-production started.

The hardware and software design of the main DAQ sub-systems have been validated.

CMS is planning to install the detector in time for the first pilot run (Fig.14).

C. ALICE

Good progress is reported for the Silicon Pixel Detector (SPD). The prototypes are available for the pixel read-out chip and the sensor wafers; the thinning of the former wafers has succeeded down to 150 μm while that for the sensor wafers has reached 200 μm. Read-out modules near the detector have been produced, while those on the DAQ side are still under development. Tests of prototype ladders in the beam have validated the performance of the detectors.

Good progress is also reported for the Silicon Drift Detector (SDD). Pre-production of the detectors has started and several of the ancillary equipment, such as the probe stations, HV connections and power supplies, are available. Tests of the read-out chips, PASCAL and AMBRA, have proven their functionality. The only concern remains with the bonding of the read-out chips to the micro-cables.

The progress on the Silicon Strip Detector (SSD) construction is also good. All sensors from the pre-series are within specification. The chips for buffering the analog signals (ALABUF), and the hybrid control signals (ALCAPONE), have been produced. Significant improvement in yield was reported on the HAL25 read-out chips. Therefore all three Inner Tracking System projects are approaching the series production phase and, although time is pressing, are committed to deliver the final detectors at the beginning of 2006. The status of the High Momentum Particle Identification Detector (HMPID) is very good. One of the 7 modules has been built and the others will be completed by the end of 2004. The CsI evaporation of the photo cathodes will start in March 2004; the quantum efficiency will be checked with cosmic rays and in test beams. Moreover, all photo-cathodes will be checked after evaporation. The detector is scheduled to be ready for installation in December 2005.

Good progress was reported on the MRPC Time-of-Flight (TOF) detector strips. The very good results obtained last summer in a test beam have validated the design. The construction of the chambers is starting.

No major concern is expressed for the Transition Radiation Detector (TRD). The construction and testing of the prototypes has progressed well. Beam tests results have shown that the π rejection, the position and the angle resolutions, the multi-layer performance and the read-out electronics are within the ALICE requirements. Good progress was reported on the read-out chips.

The construction of the Time Projection Chamber (TPC) is advancing very well and most of the components have entered the production phase. The outer and inner gas vessels are ready. The construction of the read-out chambers has started. It is reasonable to expect that the detector will be completed on time for its installation and integration within ALICE at Point 2.

The Zero Degree Calorimeters (ZDCs) continue to progress satisfactorily. The project follows the agreed schedule and is considered to be on time.

Good progress was shown in all areas of the Photon Multiplicity Detector (PMD), including the design, prototyping, and the front-end electronics. The LHC

Committee has received the last version of the PMD Technical Design Report at the September meeting this year.
The di-muon Spectrometer in the forward region consists of the absorbers, the dipole magnet, the trigger chambers and the tracking chambers. Engineering and tendering of components for the absorbers continues. Good progress is reported on the detectors for the tracking stations and the associated MANAS front-end electronics.
The conceptual designs for the Central Trigger Processor (CTP) and the Local Trigger Unit (LTU) are complete. The detailed design of the LTU has begun. Moreover, the software framework has been established and development is now underway, while the detailed simulation of the trigger response continues.
Milestones for 2003 include the submission of the Trigger/HLT/DAQ TDR in December.
The ALICE software and computing projects are progressing well. The ALICE team has made significant contributions to the experiment through the successful implementation of the software framework based on AliRoot and AliEN (the ALICE interface to the GRID) and of the Data Challenges.

D. LHCb

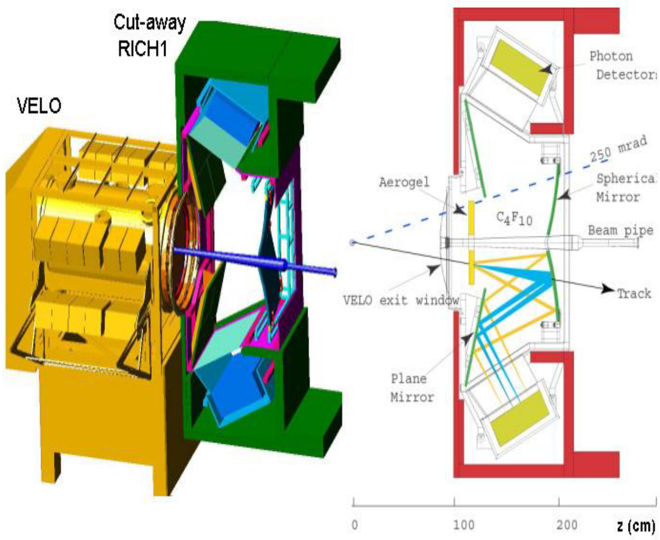
The LHCb Collaboration has made very significant progress towards the realization of an experimental set-up ready to record proton-proton collisions during the first LHC operations in April 2007. In particular, all detector technologies to be used, except for the RICH photo-detectors and the inner part of the M1 muon chamber where a very high rate is expected have successfully gone through the R&D phase. The Vertex Locator, the Inner Silicon Tracker, the straw tube Outer Tracker, the RICH Detectors, the Calorimeters, the Muon System, the Trigger System, the Computing and the Software are in construction.
The re-optimization of the LHCb detector design, while keeping the physics performance specified in the Technical Proposal, has led to a more elegant experiment, with no tracking chambers in the dipole field and use of the residual magnetic field in the Vertex locator to measure the particle momentum at trigger level. The LHCb re-optimization Technical Design Report, the related Trigger Technical Design Report and the Trigger Tracker Technical Design Report were presented in the September 2003 meeting of the LHC committee (Fig.15)

Fig.15- Front pages of the LHCb Technical Design Reports.

Remaining is the Computing TDR.

The physics performance study indicates that the physics aims given in the Technical Proposal will be met with the re-optimized LHCb detector but further work is needed to complete the physics assessment, including the evaluation of the expected background, and a detailed evaluation of systematic uncertainties.
The design of the Vertex locator, mechanics and silicon detectors, is completed. The construction has now started.
The design of the new RICH-1 detector, modified to have magnetic field in the interaction region in order to have a momentum cut at the first level trigger (Fig.16), is approaching completion. The major concern remains the delay in the choice of photo detectors. The construction of the RICH-2 detector has started

Fig.16- The VELO and the RICH1 detectors of LHCb.



The construction of the electromagnetic and the hadronic calorimeters (ECAL and HCAL) is progressing very well. The start of the SPD and PreShower construction is imminent. Although the electronics schedule is tight, the main components are close to their final design and have already undergone extensive prototyping.

Good progress is also reported on the LHCb Online System. In addition, the LHC Committee noted the carefully designed software framework and the provision of common components and tools, developed in part with EP Division and the LCG, for the offline software. Migration of the software to C++, as well as event Monte Carlo production and the Data challenges are well underway.

The LHCC considers that although a significant amount of work lies ahead, it is realistic to expect to have a working detector installed in time for the beginning of LHC operation in April 2007 (Fig.17)

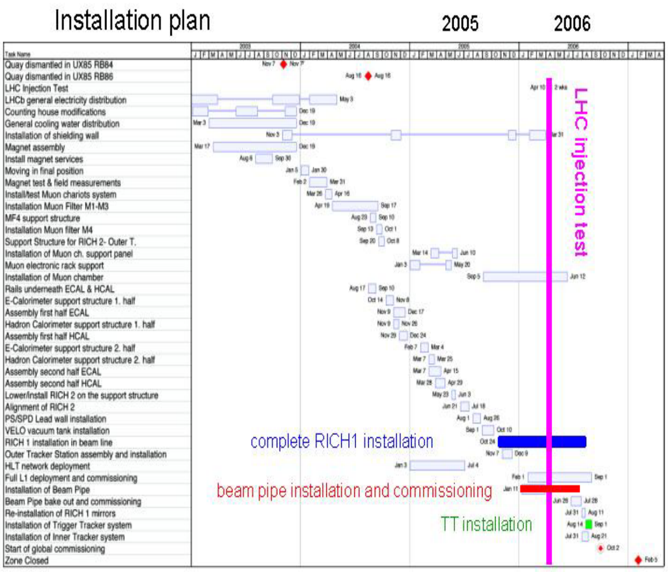


Fig.17- The LHC-b general installation planning.

III. CONCLUSION

The LHCC considers the four large experiments, which have to be operational in April 2007 in the interaction regions, are in an advanced state of construction. The 8 magnets will be assembled in the course of 2004. The detectors are in the mass production phase. A few concerns are present for some detectors, like the ECAL and the Tracker of CMS, and some electronics in the case of ATLAS. Nevertheless, even in these cases, it is possible to have them partially installed, in time for the pilot run. The four big experiments are becoming a reality. They will be on the floor at the beginning, with low luminosity, for the commissioning of the detectors, the electronics, the trigger systems, the DAQ systems and the software environment, including the GRID technology to be used in the analysis.

It is possible to envisage a sufficiently long shut down, after the pilot run, for the final installation of the staged detectors.

I wish to thank the LHC committee members for their hard and dedicated work, and also the representatives of the four collaborations, the spokesman and the project leaders, for their collaborative participation at the LHCC meetings.