Status of CMS

Progress Summary Report for April 2002 RRB

In the recently announced schedule for the LHC machine first beam is due to circulate in April 2007, with first collisions due to occur in June 2007. The master assembly sequence now effectively being followed is Draft v33 which is based on completion of the complete CMS detector, minus the staged items for high luminosity running (ME4/1 and ME4/2 and the 3rd forward pixel disks), in time for physics in mid-2007. However, the construction progress is still being monitored with respect to v31 which called for a physics run in August 2006. The list of milestones will be updated for the October LHCC CMS Comprehensive Review to enable monitoring w.r.t. v33. This will be reported to the October 2002 RRB.

Civil Engineering and Assembly

Status
The excavation of the two underground caverns USC55 (services) & UXC55 (experiment) is more than 50% complete and is now below the level of the LEP tunnel. The delivery of these caverns is now foreseen for mid-July 2004. The construction of the shielding plug will be now be carried out by the main contractor, and this secures the main civil engineering schedule. However, for reasons of cost, the CMS specific secondary concreting will have to be handled by smaller contractors outside the main CE windows. The CMS experimental cavern will thus be ready to receive detector elements around April 2005.

Changes
The delivery of the underground caverns USC55 and UXC55 has shifted from April to mid-July 2004.

Plans and milestones for 2002
The excavation of the underground caverns has started and will continue through 2002.

Concerns
The critical path goes through timely delivery of the equipped underground caverns UXC55 and USC55.

Magnet

Status
All five barrel yoke rings and six endcap disks of the magnet yoke have been assembled at Point 5. The coil-swiveling platform has been delivered to Point 5 and is being used for the mock insertion of the coil (simulated by suitably loaded inner vac-tank). Gangways and services will be installed on the barrel and endcap yokes.

The Rutherford cable is being produced at Brugg Kabelwerk (Switzerland) and seventeen (out of 20+2) lengths have been produced. Fifteen (out of 20+1) lengths of the insert (Rutherford cable co-extruded with pure aluminium) have been produced at Nexans, Switzerland (formerly known as Cortaillod). Six (out of 20+1) good lengths (2’650m) of the conductor (sc strands, pure Al insert and Al alloy reinforcement) have been produced at Techmeta, France.

A substantial delay in the winding operation has occurred. This has been caused by the two contracted companies canceling the contracts for the supply of the special 60 mm

thick plates in high strength aluminum alloy for the mandrels. In addition it was not possible to find an alloy in the suitable state for the flanges; a special fabrication method (hot roll milling) has had to be adopted. The winding machine has been tested at Ansaldo (Italy). The winding of the prototype coil has started.

Changes
Delivery of the last coil module has shifted from May 2003 to December 2003. The magnet will now be tested on the surface in Q1-05. This is in accord with the draft v33 planning.

Plans and milestones for 2002
The first coil module should be finished towards the end of 2002.

Concerns
Coil winding. The critical path goes through the surface magnet test.

Tracker

Status
Some 50% of the Silicon Strip Tracker budget has been committed. The procurement of opto-electronics and some important parts of mechanics is well advanced. The first batch of industrially produced hybrids was received in January 2002. Many Si modules from the Milestone 200 have been produced in different production centers. All control and front-end ASICS have been finalized and the final masks for production have been submitted. The first small sub-system (outer barrel 'rod') has been equipped with modules. The start of module production has shifted to November 2002 to lower risk and allow savings in the production of front-end hybrids. Significant progress has been made on Tracker DAQ and monitoring aiming at integration within the global CMS DAQ. Good progress has also been made in reconstruction software and the use of the Tracker in High Level Trigger (HLT). The final DMILL chip for pixel readout was submitted in December and the conversion to 0.25 micron technology started in January.

Changes
The start of Si module production has been shifted from June 2002 to November 2002.

Plans and milestones for 2002
Test of large (12-30 modules) subsystems with final FE ASICS, optoelectronics and prototypes of power supplies with long cables. Select the FE hybrid technology by June 2002. Start of mass assembly of modules in November 2002.

Concerns
Timely production of large quantities of FE hybrids and pitch adapters.
Shortfall in funding.

Electromagnetic Calorimeter

Status
All the 138 ovens, at BTCP, Russia, have been modified to enable the growing of larger crystal boules. The last batch of barrel crystals is due to be delivered in Q4-04. Offers are in hand for the endcap crystals but lapse at the end of this year. The expected rate of 5000 APDs / month has been reached and about 25,000 of the 130,000 APDs have been deliv-

ered. The first 500 production VPTs have been received. The CERN and Rome regional centres have started the assembly of modules for the first Supermodule (SM1).

Some modifications to the construction of the 'superbasket' were suggested by the EDR on barrel mechanics carried out in January 2002. These will be validated on the first supermodule with a pre-series superbasket.

As a cost control measure, to eliminate cost overruns, over and above those indicated at the October 2001 RRB, the baseline electronics design has been changed so that the Level - 1 trigger primitive is generated on-detector rather than off-detector. This decreases by a factor of ~10 the number of optical links that transport the data out of the detector. Consequently the volume of the off-detector electronics is also reduced. There is no impact on physics performance but the flexibility is somewhat reduced. A new ASIC has to be made in 0.25 μm CMOS radiation-hard technology and modifications are required in the electro-mechanics behind the grid of the SM. These changes are now underway. The ECAL should be completed and commissioned by April 2007 thus respecting the v33 schedule. The final design review of the FPPA was conducted in February 02 and the chip will be re-submitted in April 2002.

It is no longer planned to calibrate all the supermodules and Dees in the test beam prior to installation. The plan now asks for a detailed study of a few SMs (and 1 Dee) and a calibration of at least 9 SMs in beams in 2004 (for the SMs) and 2006 (for the Dee).

Pre-shower: The sensor production has started in Russia and recently in India. Many tests of the electronics have been carried out and the final DMILL version of the PACE chip will be submitted soon. Work has started on the backup in 0.25 μm technology.

Changes
Cost overruns, over and above those indicated at the October 2001 RRB, became apparent at the end of 2001 in a further Cost Review of ECAL. To contain costs the architecture of the electronics chain has been modified: the Level-1 trigger primitive will now be generated on-detector rather than off-detector. The ECAL electronics team has been reorganized. Synergy between the tracker and preshower projects has been introduced.

Plans and Milestones for 2002
EE EDR in mid-2002.
Assemble a few 'bare' SMs without the front-end electronics during 2002.
Beam test of module M0' (~ 400 crystals).
Start preparing a SM with final analog electronics and an emulated digital part (with Xilinx FPGAs) to validate the electro-mechanics and analog electronics chain.

Concerns
Several changes have been made and holding to the tight schedule is a major concern: timely introduction of new manpower resources is vital.
Assurance of funding.

Hadron Calorimeter

Status
All the barrel (HB) absorber has been delivered to CERN. All the HB optics (scintillator and fibres) for the barrel is completed, delivered to CERN, installed in HB and tested. The HB-1 half-barrel has been assembled at Point 5. The HE-1 (Hadronic Endcap on –Z side) absorber has been delivered to CERN, and the optics manufacture is nearly complete. It will be shipped in time to begin HE-1 assembly in 2002. Mass manufacture of the HF wedges has commenced and the first 9 of 36 total have been delivered. The HF quartz fibres and photomultipliers have been ordered and tested and first deliveries have been

made. One third of the HO scintillator tiles have been machined and the pigtail manufacture has started.

The HPDs are under contract and the first 20 have been delivered and tested satisfactorily. The QIE and CCA chips from the first submission have been evaluated. It has been decided to go directly into production, skipping an engineering cycle. A single channel has been read out through prototype electronics all the way from HPD through to DAQ. The stability was found to be very good, and the radioactive source calibration using the normal data path has been validated.

Changes
The HE optical decoder unit has been configured to deliver signals from 2 longitudinal compartments. Electronics has been added to allow for signals from HO and both HE compartments to be used in the Level-1 trigger.

Plans and major milestones for 2002
Both the half-barrels of the HB will have been assembled by Q4-02. Schedule permitting, several modules of the 2nd half-barrel will be calibrated in test beam in 2002.
HE+1 absorber and optics should be delivered by the end of 2002. The front end production electronics will be placed under contract in 2002.

Concerns
None.

Muon Detector

Status
Endcap CSCs: 76 out of 148 CSC chambers have been manufactured at Fermilab (US). Production has started at IHEP, Beijing, at PNPI, St Petersburg and at JINR, Dubna. Each site has assembled about 10-15 CSCs, the rate of production has reached close to the planned rate. The production of anode and cathode front-end electronics boards is proceeding as planned. The FAST (Final Assembly and System Testing) sites at the Universities of Florida and UCLA have started the assembly of chambers with front-end electronics. The CSC installation fixture has been designed and produced at the University of Wisconsin and successfully tested at CERN. The funds for electronics and skew-clear cables for ME1/1 have been made available from the US contingency.

Barrel Drift Tubes: The sites at CIEMAT, Aachen and Legnaro have assembled 36, 25 and 19 superlayers respectively. Fifteen chambers have been assembled and five are at CERN. The delay in the assembly of complete chambers has been caused by some difficulties encountered in the procurement of honeycomb panels that are flat enough. It is anticipated that the new deliveries will be satisfactory. The plate electrode and I-beam electrode manufacture has reached nominal speed at Dubna and IHEP, Protvino in Russia. The procurement of electronics sitting inside the gas volume is on schedule. The TRACO chip has now been successfully tested and ordered.

RPCs: The gap production for the barrel has started; 96 gaps and 4 chambers have been manufactured.

Alignment: The second EDR was successful and approval was given for the production of the elements needed for the surface Magnet test in 2005. A prototype of the MAB is ready for measurement.

Changes
The start of the mounting of the DT chambers has been delayed until 2003.

ME4/1 has been restaged. The cost of the ME1/1a electronics has been lowered by reducing the number of electronics channels.

Plans and milestones for 2002
CSCs: Mounting on the endcap yoke disks will start in late 2002.
Barrel Drift Tubes: Assemble around 70 DT chambers. A trial mounting of one sector in one yoke wheel will be made in 2002.
RPCs: Finish the production for the barrel central wheel. Decide by June 2002 whether or not to coat forward RPC bakelite with oil.

Concerns
DTs: rate of chamber production, parts flow although there has been good experience recently. Delivery of electronics housed outside the gas volume in the on-board mini-crates.
RPCs: rate of production of RB chambers. Timely production of RE1 chambers.

Trigger and Data Acquisition

Status
Trigger: Final full-function prototypes of many elements are being constructed and tested. Testing of a set of second-generation prototype calorimeter trigger cards is underway. Prototypes of a new low-latency compact CSC trigger are being designed. Production has started on the ASICs for the Drift Tube Trigger. Successful tests of the Optical Link system for the RPC trigger have been performed. The control logic system for the Global Trigger has been designed.

DAQ: The continuation of prototypes and demonstrators tests has been driven by the baseline design that will be described in the DAQ TDR. The Event Builder (EVB) design has evolved into a more modular architecture allowing an easier upgrading as technology evolves. This results in a DAQ system comprising 8 independent systems (slices). A slice can read up to 12.5 kHz. This design allows natural staging/commissioning phases. It comprises the use of the Myrinet technology both to transmit the data to surface and to build the events in the Filter Farm processors. The major elements of a DAQ column from the output of the Front-End digitizers, the data mergers, the FED builder, the data link up to the input into a Readout builder have been developed and integrated in test benches currently under study.

Changes
There are no significant changes.

Plans and milestones for 2002/2003
Trigger: Move into the phase of prototypes integration-conduct systems tests between trigger sub-system prototypes and with detector front-end electronics prototypes. Begin production on long lead-time components.

DAQ: Submit the DAQ TDR at the end of 2002. After the approval start the construction of a preseries system and the engineering of the custom-design components for the final system.

Concerns
The time available for installation and commissioning in the underground area.

CPT

Computing and Core Software, Physics Reconstruction and Selection, Tridas

Status

Computing and Core Software: Large-scale event generation for the Physics Reconstruction and Selection Groups is being completed. Twelve prototype regional centers worldwide, comprising 24 actual computing sites, are participating in this exercise. The substantial complexity and shortage of expert manpower led to delays w.r.t. the milestone set. To date we have used Objectivity as the Event-store technology. Reconstruction software is well advanced and in use. A new version of the interactive toolkit IGUANA will be released in 2002 (IGUANA4). It will offer to the developers of physics algorithms in the PRS groups a 3D detector and event display to debug ORCA (CMS event reconstruction) and OSCAR (CMS event simulation based on GEANT 4). IGUANA4 can also be used to visualise and debug the Detector Description Database (DDD).

PRS: The High Level Trigger (HLT) code has been improved and new elements have been added. The triggering strategy for the startup instantaneous luminosity of $2x10^{33}$ $cm^{-2}s^{-1}$ has been studied, and a first estimate of the output rate to storage (80Hz) is now available. The effect of a potentially staged Trigger/DAQ system at startup has also been studied, and trigger tables are now available for both 75kHz and 50kHz DAQ bandwidth capability. The effect of staging some sub-detector elements has been studied.

Changes

As discussed in the last report, various commercial, technical and manpower concerns have prompted us to change the baseline for persistent data from our current Objectivity/DB solution. We are actively following a so-called "hybrid" data-store approach based on an object streaming layer (ROOT) and a (probably commercial) Relational Database catalog and navigation layer. This design and development is being performed as part of a joint project with all LHC experiments and the LHC Computing GRID project.

Plans and milestones for 2002

More detailed tuning of GEANT4 simulation software. We have a fully operational GEANT4 application interfaced to our Software Framework; current work is in validation of the Physics and Detector Descriptions in the program and in GEANT4.

DAQ TDR: Provide support software and event-generation for HLT studies. Study HLT for high luminosity operation. Establish DAQ parameters for the TDR.

Increasing use of GRID test-beds to assist in our worldwide productions, and to validate the GRID deliverables. We have recently published a detailed CMS GRID Implementation plan for 2002.

The major activity will be designing and then developing common tools, frameworks and architectures for our Software in the context of the LHC Computing GRID and together with the other three LHC experiments.

Concerns

The changed LHC startup date and the impact of the LHC Computing GRID project, both of which are expected to have a positive effect on our resource problems, nevertheless necessitate changes in much of our long-term planning and this is now underway.

Overall Milestone Completion

In Fig 1, the intended and achieved integrated numbers of milestones completed are compared month by month. It should be noted that milestones dates based on the v31 planning were used for this comparison, whilst several sub-systems are already adapting their planning to v33. Eighty three percent of the intended Level 1 and Level 2 milestones were completed.

Conclusion

CMS is now following a draft assembly planning, v33, that allows a complete detector (except for ME4/2 and 3rd forward pixel layer) to be ready for the first physics run in 2007. A re-baselining of milestone dates is inevitable in the light of this new LHC machine schedule and will be completed for the next RRB.

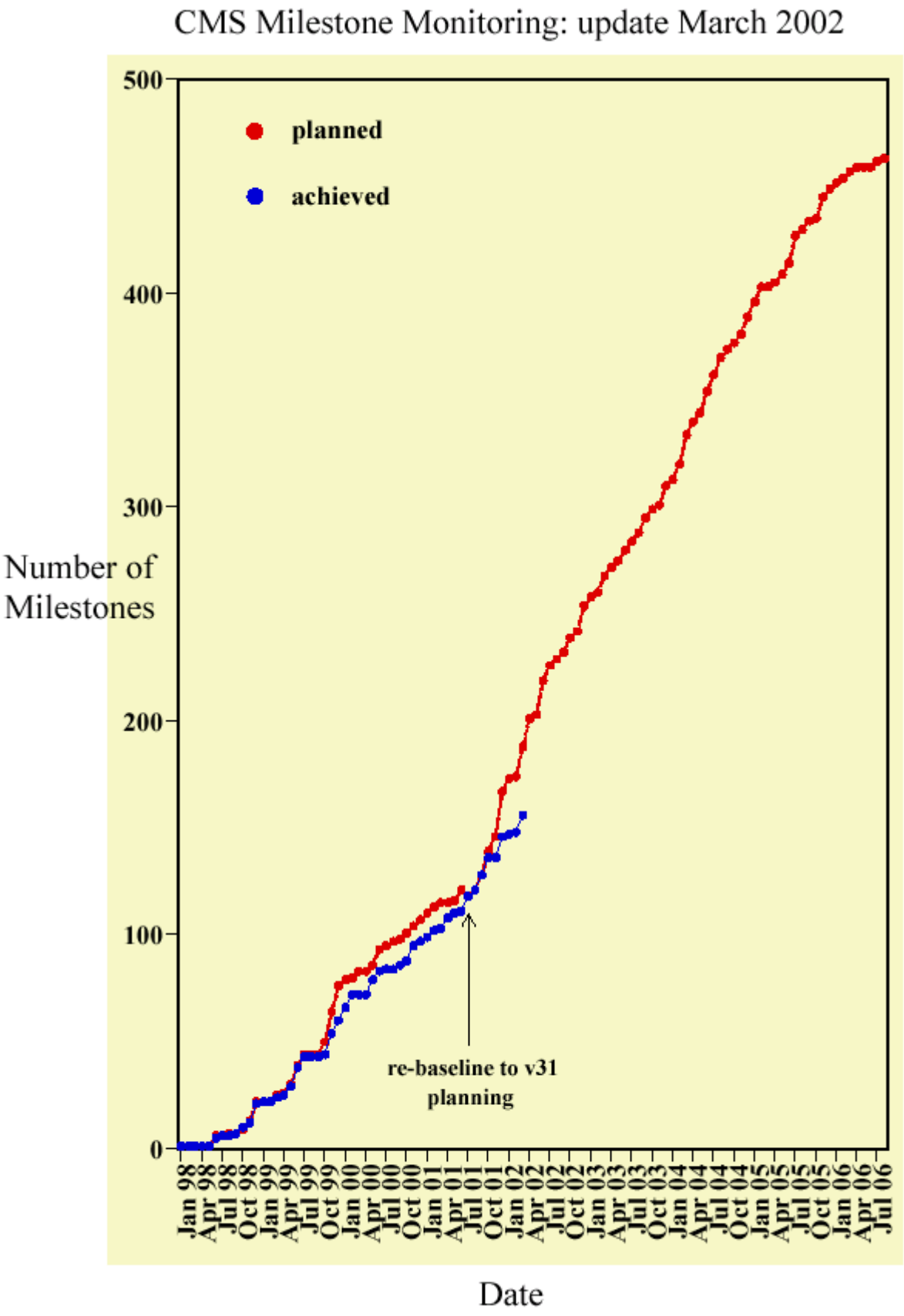
CMS Milestone Monitoring: update March 2002
planned
achieved
re-baseline to v31
planning
Number of Milestones
Date
0
100
200
300
400
500
Jan 98
Apr 98
Jul 98
Oct 98
Jan 99
Apr 99
Jul 99
Oct 99
Jan 00
Apr 00
Jul 00
Oct 00
Jan 01
Apr 01
Jul 01
Oct 01
Jan 02
Apr 02
Jul 02
Oct 02
Jan 03
Apr 03
Jul 03
Oct 03
Jan 04
Apr 04
Jul 04
Oct 04
Jan 05
Apr 05
Jul 05
Oct 05
Jan 06
Apr 06
Jul 06

Figure 1.