STATUS OF TOTEM

Progress summary report for the November 2008 RRB

Introduction

The TOTEM experiment has been described in detail in the document presented to the October 2007 RRB. Therefore in this document, we concentrate on the progress made in 2008 and the expected final installation of the complete experiment. During the year 2008, the three subdetectors have been tested with the final electronics and for each subdetector, a production line with final tests has been established. A detailed plan is attached.

The aim is to install the complete TOTEM experiment before summer 2009 with one exception: the Roman Pots at the high radiation stations (147 m from the IP) will only be partially equipped in order to gain preliminary experience with the radiation and to save some Silicon detectors for the case of unexpectedly high radiation levels.

We envisage that the TOTEM experiment will operate continuously as soon as the LHC begins running. The experience gained during the low luminosity start-up phase will enable us to use efficiently the short duration runs with our specialized optics, which will hopefully be commissioned during 2009.

The T1 CSC Telescope

The T1 inelastic telescope is designed to detect the passage of charged particles in the pseudorapity range $3.1 < |\eta| < 4.7$. It will be installed, on either side of the interaction point, in the space between the LHC beam pipe and the inner envelope of the CMS endcaps. Each "arm" of the telescope consists of five layers of wire chambers with cathode strip read-out (CSC). Each chamber, of trapezoidal shape, covers approximately 60° in azimuth, so that 6 chambers are needed to complete a layer; because of the geometry and space constraints of the detector, overall 10 different shapes are required. Each arm is split vertically into two "half-arms", with independent support structure, services and read-out chains.

The CSC are assembled at PNPI in Gatchina, Russia. Out of 70 chambers needed in total (60 + 10 spares), 62 have been completed. For 51 of them the acceptance tests performed at PNPI have been successfully repeated at CERN.

The read-out electronics has been fully developed and successfully tested. It includes the anode front-end cards (AFEC: 10 different types), the cathode front-end cards (CFEC: fully digital read-out) and the concentrator boards (ROC). The first production series allowed to equip one "half-arm" (1/4 of the total); production of the remaining boards will start soon. About one third of the VFAT front-end chips and of the small PCB hosting them have been received the rest will follow in time. All low voltage and high voltage power supplies (mainframes and modules) have been delivered.

A storage/test/assembling area has been set up at building 188 at CERN. Cosmic rays tests are currently undergoing, with the final read-out chain and power supplies, and a DAQ system using the same hardware as the final one. One half-arm of the detector has been fully assembled, with complete local cabling and piping. All pieces making up the support structure for the two arms have been produced in Genova and assembly-tested with CSC mock-ups.

Table 1: Planning for the T1 detector

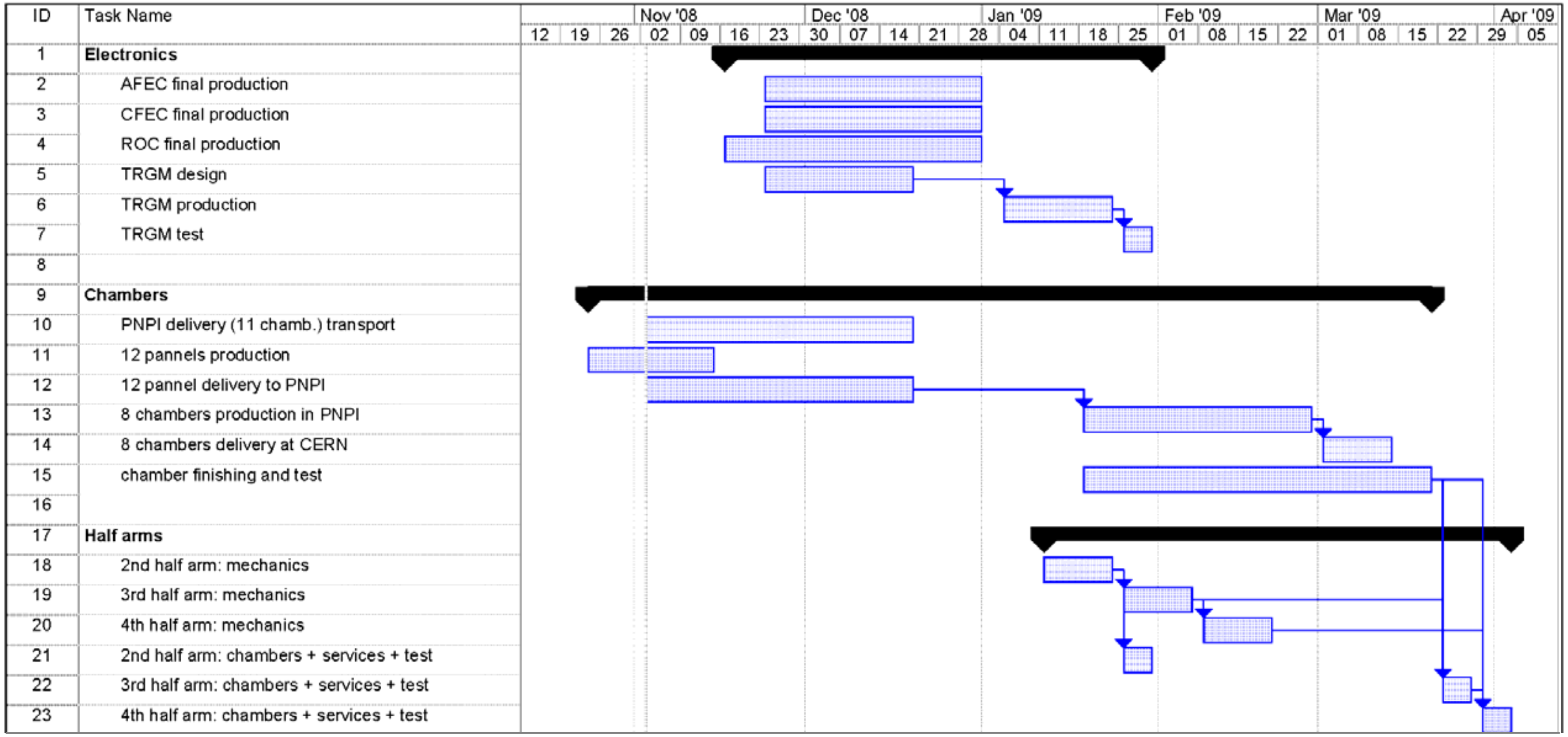


Table 1 shows the planning for the production and the final tests of the complete T1 detector, including electronics and the mechanical structures. After having passed the cosmic ray tests, the detector will be ready in April 2009 for installation into the CMS environment.

The T2 GEM Telescope

The T2 telescopes are installed in the forward shielding of CMS between the vacuum chamber and the inner shielding of the HF calorimeter. In each arm, 20 semi-circular GEM planes are interleaved on both sides of the vacuum chamber to form 10 detector planes with full azimuthal coverage. The gaseous electron multipliers (GEM) detectors were chosen because of their high rate capability, good spatial resolution, robust mechanical structure and their excellent ageing characteristics.

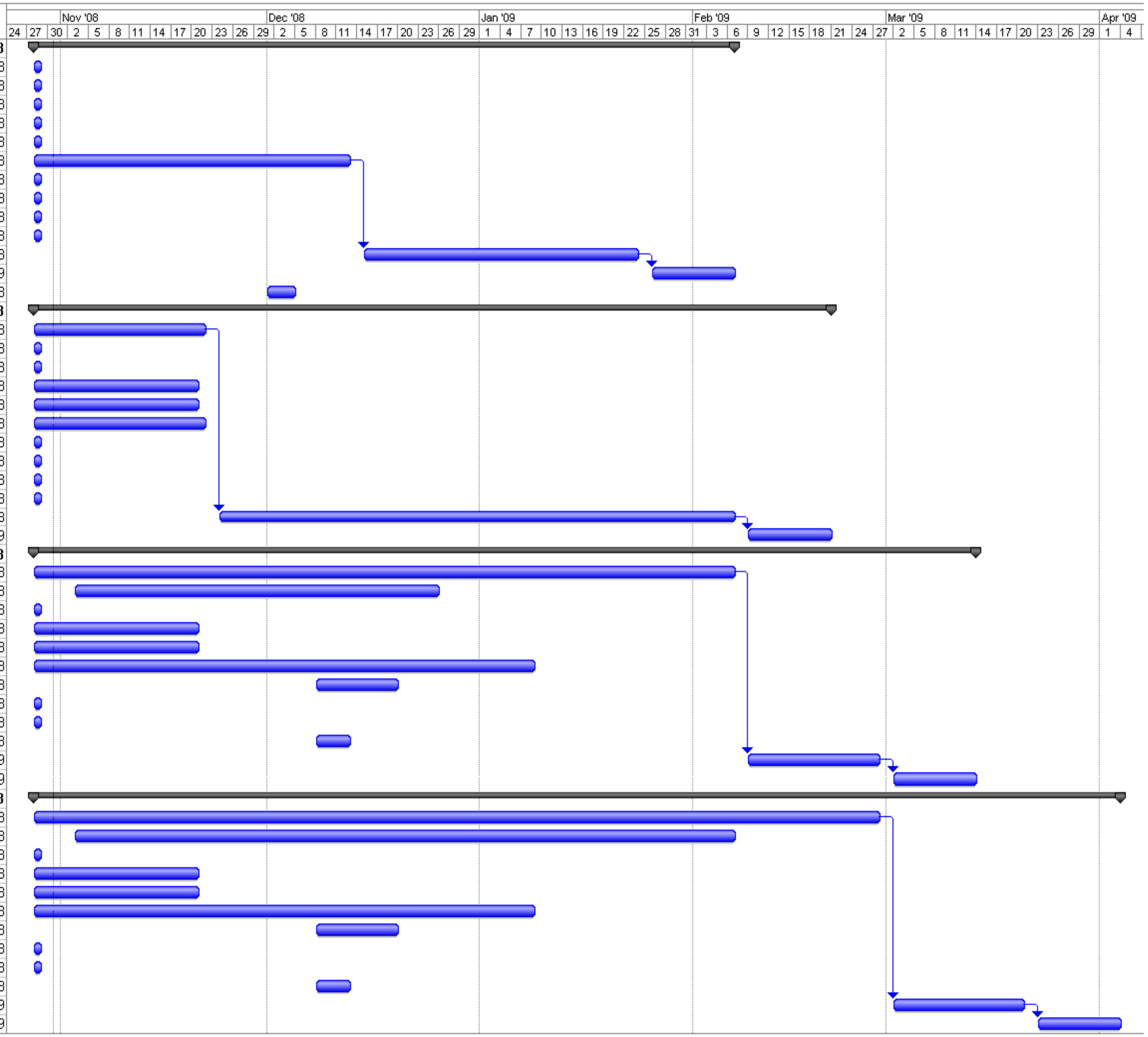
All GEM chambers were produced in Helsinki in the clean rooms of the Detector Laboratory where a dedicated assembly line was set up. The production of 50 GEMs (40 for T2 plus 10 spares) terminated about a year ago. An extensive effort, partly automated, ensured highest quality control. It included leakage current measurements of the GEM foils, optical inspection of the foils and search for broken or short-circuited strips/pads on the readout board, and finally a ^{55}Fe source test.

During summer 2008 the readout electronics has been finalized and tested. The first quarter of the T2 telescope was assembled and fully equipped with electronics to be systematically tested in the SPS beam line H8 where also cabling and shielding were optimized with respect to noise reduction. These extensive tests were a common effort of the Pisa/Siena, Helsinki and CERN groups. After some optimization, the operation of the GEM chambers was fully satisfactory and according to expectations. During August 2008, this first quarter telescope was then installed in IP5 in view of obtaining first results from LHC collisions. However, these chambers have now to be temporarily removed during the coming shutdown in order to stiffen its mechanical structure, which has shown some instability due to the unexpected strong magnetic field in the forward region of CMS.

The second quarter is presently assembled in the TOTEMINO facility on the H8 line, with tests done with cosmic rays due to the lack of beam. In the meanwhile, the third and fourth T2 quarters chambers are being fully assembled and tested in their final configuration in Helsinki. The final mechanical assembly with the readout electronics of the second telescope will be carried out at CERN. In compliance with the CMS schedule, the complete T2 telescope, fully instrumented, is expected to be installed in IP5 between January and March 2009, as shown in the planning in Table 2.

Table 2: Planning of the T2 telesope

Task Name	Duration	Start
1st quarter	**74 days**	**Tue 10/28/08**
Chambers	1 day	Tue 10/28/08
Hybrids	1 day	Tue 10/28/08
Horse Shoes	1 day	Tue 10/28/08
11th Card	1 day	Tue 10/28/08
OptoTX	1 day	Tue 10/28/08
Mechanics	34 days	Tue 10/28/08
Cables	1 day	Tue 10/28/08
Cooling pipes	1 day	Tue 10/28/08
Gas pipes	1 day	Tue 10/28/08
Supports	1 day	Tue 10/28/08
Tests	30 days	Mon 12/15/08
Installation	10 days	Mon 1/26/09
Remove from IP5	4 days	Mon 12/1/08
2nd quarter	**84 days**	**Tue 10/28/08**
Chambers	19 days	Tue 10/28/08
Hybrids	1 day	Tue 10/28/08
Horse shoes	1 day	Tue 10/28/08
11th Card	18 days	Tue 10/28/08
OptoTX	18 days	Tue 10/28/08
Mechanics	19 days	Tue 10/28/08
Cables	1 day	Tue 10/28/08
Cooling pipes	1 day	Tue 10/28/08
Gas pipes	1 day	Tue 10/28/08
Supports	1 day	Tue 10/28/08
Tests	55 days	Mon 11/24/08
Installation	10 days	Mon 2/9/09
3rd quarter	**99 days**	**Tue 10/28/08**
Chambers	74 days	Tue 10/28/08
Hybrids	39 days	Mon 11/3/08
Horse Shoes	1 day	Tue 10/28/08
11th Card	18 days	Tue 10/28/08
OptoTX	18 days	Tue 10/28/08
Mechanics	53 days	Tue 10/28/08
Cables	10 days	Mon 12/8/08
Cooling pipes	1 day	Tue 10/28/08
Gas pipes	1 day	Tue 10/28/08
Supports	5 days	Mon 12/8/08
Tests	15 days	Mon 2/9/09
Installation	10 days	Mon 3/2/09
4th quarter	**114 days**	**Tue 10/28/08**
Chambers	89 days	Tue 10/28/08
Hybrids	70 days	Mon 11/3/08
Horse Shoes	1 day	Tue 10/28/08
11th Card	18 days	Tue 10/28/08
OptoTX	18 days	Tue 10/28/08
Mechanics	53 days	Tue 10/28/08
Cables	10 days	Mon 12/8/08
Cooling pipes	1 day	Tue 10/28/08
Gas pipes	1 day	Tue 10/28/08
Supports	5 days	Mon 12/8/08
Tests	15 days	Mon 3/2/09
Installation	10 days	Mon 3/23/09



Roman Pot detectors

All Totem Roman Pot stations have been mounted and integrated into the outcoming beam pipes on both sides of IP5. The cabling and the piping are completed at the points at 220 m away from the IP. For the other stations it will be finished before the end of 2008.

We are now in the process of installing the detector packages in the Roman Pots. Each detector package is made of 10 precisely mounted planes of hybrids containing one edgeless silicon sensor and four VFAT readout/trigger chips in a secondary vacuum. A common motherboard reads the data and feeds them through a gastight vacuum flange to the outside DAQ. Two detector packages have already been installed at the farest stations at 220m away from IP5 at each side. This has allowed to complete the commissioning of the cooling station which has been installed centrally in IP5 to serve the Roman Pot systems at both sides. It has shown the expected results: a temperature of -33°C in the pot without heat load, corresponding to about -20°C at full load.

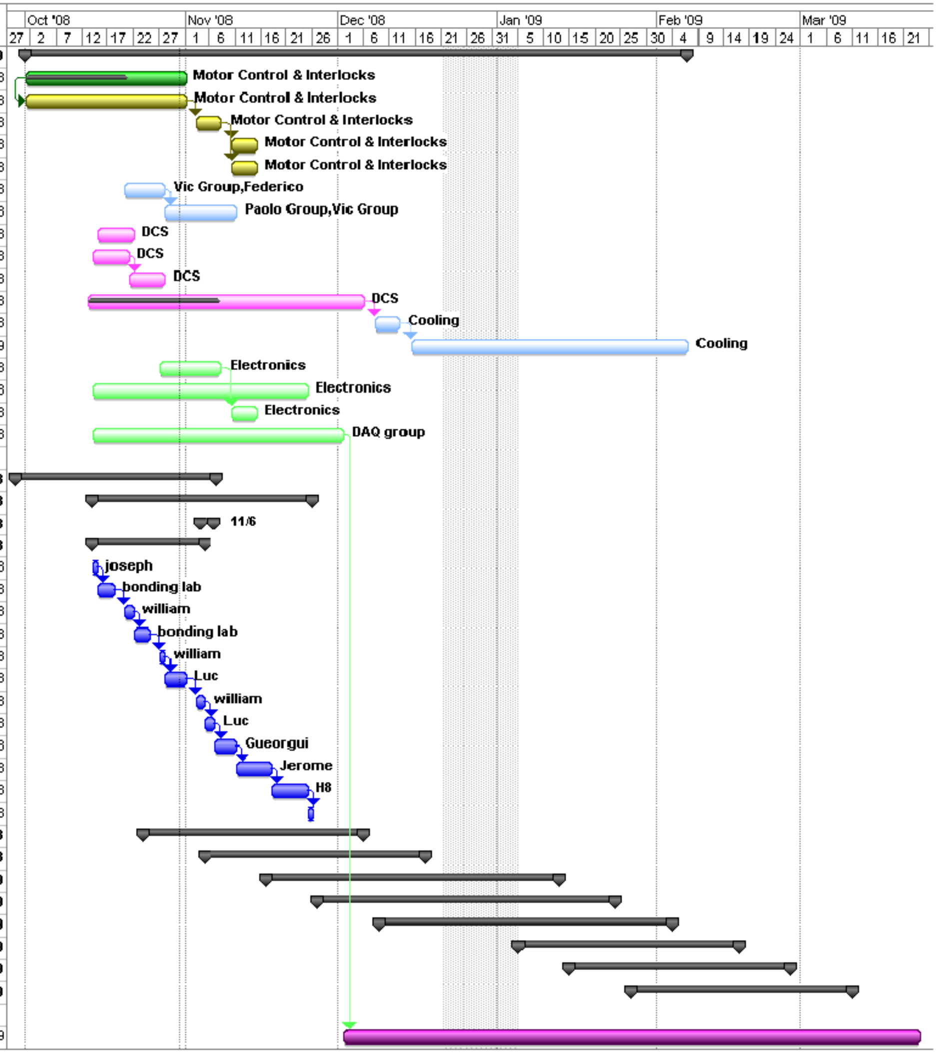
The mounting of the detector packages follows a detailed sequence of characterization and quality control between the different assembly steps. These activities require the use of the PH DT Silicon Detector facility for testing the Si sensors, the TOTEM Test Platforms for testing the VFAT chips (2 set-ups are now available close to the bonding Lab in the former CMS Tracker Test Infrastructure), the chip gluing and the bonding machines of the PH DT group and the Computer Measuring Machine, also available in the bonding lab, to precisely control and measure the position of the sensors on the hybrids. The assembly of the detector package is completed with the precise mounting of the ten hybrids in a stack equipped with capillaries and cooling pipes and the “champignon” vacuum flange. For the test of the separated Motherboard and its mezzanine cards a specific setup based on VME electronics has been developed and is now available in the TOTEM Lab.

Before installation in the tunnel, each detector package has to be tested in the H8 beam area where a reduced version of the final DAQ and Data monitoring system allows to test the full functionality of the detectors and the front end electronics with cosmic rays replacing the originally foreseen SPS beam. During these tests the detector packages are hosted in vacuum in a prototype pot, cooled down with the “H8 Cooling Plant” and controlled with a mini-DCS developed on purpose for H8 to run in the same environmental conditions than the ones foreseen for the running of the experiment.

With the full VFAT chip production and all needed Si sensors delivered, hybrids are mounted and the detector packages are assembled as the hybrid boards become available. For the time being the pots 3, 4 and 5 are being assembled, following the plan to produce the 12 detector packages needed to equip all pots of the RP Stations at 220m by the end of March and to complete the production for the summer 2009. The planning for the production of the Roman Pot Detector packages for the stations at 220m is shown in Table 3 together with a detailed production sequence for Pot 4.

Table 3: Planning for the production and test of the next pots to complete the installation of the stations at 220m

Task Name	Duration	Start	Finish
Infrastructure	**83 days**	**Wed 10/1/08**	**Fri 2/6/09**
Fesa software+PXI integrated	23 days	Wed 10/1/08	Fri 10/31/08
Interlocks	23 days	Wed 10/1/08	Fri 10/31/08
Test of motor movement	5 days	Mon 11/3/08	Fri 11/7/08
Motor Commissioning with CCC	5 days	Mon 11/10/08	Fri 11/14/08
Survey & LVDT calibration	5 days	Mon 11/10/08	Fri 11/14/08
MiniDCS for cooling preparation	6 days	Mon 10/20/08	Mon 10/27/08
Commissioning cooling with miniD(	10 days	Tue 10/28/08	Mon 11/10/08
Install ELMB Boxes	5 days	Wed 10/15/08	Tue 10/21/08
Confirmation of pinout tables	5 days	Tue 10/14/08	Mon 10/20/08
Development (Adopt functionalitie:	5 days	Tue 10/21/08	Mon 10/27/08
I-1234	40 days	Mon 10/13/08	Fri 12/5/08
Liquid Circulation in Roman Pot wi	5 days	Mon 12/8/08	Fri 12/12/08
Cooling Test with Dummy Loads	30 days	Mon 12/15/08	Fri 2/6/09
Install cables (which cables?)	10 days	Mon 10/27/08	Fri 11/7/08
Finish Racks	30 days	Tue 10/14/08	Mon 11/24/08
Test Connectivity	5 days	Mon 11/10/08	Fri 11/14/08
Read out system	35 days	Tue 10/14/08	Mon 12/1/08
Pot 3	**29.5 days**	**Mon 9/29/08**	**Fri 11/7/08**
Pot 4	**31 days**	**Tue 10/14/08**	**Tue 11/25/08**
MB ready	**3 days**	**Tue 11/4/08**	**Thu 11/6/08**
test VFAT and Hybrid	**16 days**	**Tue 10/14/08**	**Tue 11/4/08**
Inspection	1 day	Tue 10/14/08	Tue 10/14/08
VFAT Mount	3 days	Wed 10/15/08	Fri 10/17/08
electric test 1	2 days	Mon 10/20/08	Tue 10/21/08
sensor mount	3 days	Wed 10/22/08	Fri 10/24/08
electric test 2	1 day	Mon 10/27/08	Mon 10/27/08
bars mount	4 days	Tue 10/28/08	Fri 10/31/08
electric test 3	2 days	Mon 11/3/08	Tue 11/4/08
Detector Package (DP)	2 days	Wed 11/5/08	Thu 11/6/08
MB + DP test	2 days	Fri 11/7/08	Mon 11/10/08
Champignon	5 days	Tue 11/11/08	Mon 11/17/08
H8 Test	5 days	Tue 11/18/08	Mon 11/24/08
IP 5 Installation	1 day	Tue 11/25/08	Tue 11/25/08
Pot 5	**31 days**	**Fri 10/24/08**	**Fri 12/5/08**
Pot 6	**31 days**	**Wed 11/5/08**	**Wed 12/17/08**
Pot 7	**31 days**	**Mon 11/17/08**	**Mon 1/12/09**
Pot 8	**32 days**	**Thu 11/27/08**	**Fri 1/23/09**
Pot 9	**31 days**	**Tue 12/9/08**	**Tue 2/3/09**
Pot 10	**31 days**	**Mon 1/5/09**	**Mon 2/16/09**
Pot11	**31 days**	**Thu 1/15/09**	**Thu 2/26/09**
Pot12	**31 days**	**Tue 1/27/09**	**Tue 3/10/09**
IP5 Commissioning	3.5 mons	Tue 12/2/08	Mon 3/23/09



Electronics

Table 4 shows the production and test schedule of all printed circuit boards for the TOTEM experiment.

The three TOTEM sub-detectors are using the same front-end chip: the VFAT mounted on detector specific hybrids provides both tracking and fast trigger data. The on-detector cards (Roman Pot motherboard, ROC for T1 and 11th and horseshoe card for T2) link the hybrids with front end chips to the outside world. Both trigger and tracking data are optically transmitted to the counting room where they are received by the HOST board with opto-receiver mezzanines. The counting room hardware was a shared development: the CMS preshower group designed the opto-receiver mezzanine and TOTEM the HOST board. The data can be transferred by USB, VME and Slink (for CMS compatibility).

The prototypes of the on-detector cards have now been fully tested. The development of the required preliminary versions of firmware and software took much longer than expected which delayed the mass production now expected to be completed before Christmas. Some printed circuit boards (e.g. the repeater and optocoupler card), needed in a later stage for joint runs with CMS, are still in design.

In addition, it became clear that the motor control could not generate the interlock signals for beam dump in a sufficiently reliable way, and that new dedicated electronics had to be developed. After several discussions with the machine, specifications are now finalized and the design is almost completed.

Production problems have been encountered with several boards:

The Roman Pot hybrids showed a metallization problem on about one quarter of the full production. After careful inspections and discussions with the company the problem seems to be understood and a new production has been launched.

The production of the hybrids for T1 and T2 has a low yield, and consequently about 200 hybrids still need to be produced to be completed in January 2009.

The Coincidence Chip hybrid production failed due to a processing problem. The first batch of new hybrids is expected mid November, and the rest at the end of the year.

We have just been informed about a problem with the HOST board production which is shared with CMS. This board is the main board in the counting room for data acquisition and trigger generation. 51 out of 90 boards were delivered. The rest apparently failed electrical test after components mounting. Together with CMS we are investigating further.

The installation of counting room infrastructure progressed significantly: power supplies and VME crates have been installed. For the DCS, several boards and crates were developed, which are being cabled now.

Table 4: Production and test schedule of all printed circuit boards for the TOTEM experiment.

W. S. 02.11.2008	Quantity												
	RP	**T1**	**T2**	**setups + spare**	**Total**	**who**	**design**	**proto**	**test**	**Start Prod**	**End Prod.**	**Start Test**	**End of Test**
RP Cards													
RP Hybrid	240			40	280	CERN					Nov-08	Jan-08	Jan-09
RP Motherboard	24			6	30	CERN					Nov-08	Feb-08	Dec-08
T1 Cards													
T1 anode hybrid (*)		120		20	140	Genova					Nov-08	Jan-08	Jan-09
T1 cathode hybrid (*)		360		30	390	Genova					Nov-08	Jan-08	Jan-09
Anode FrontEnd Card (AFEC)		60		10	70	Genova					Nov-08	Jan-08	Dec-08
Cathode FrontEnd Card (CFEC1)		120		20	140	Genova					Nov-08	Jan-08	Dec-08
T1 Readout Card (ROC)		40		5	45	Genova					Nov-08	Jan-08	Dec-08
T2 Cards													
GEM strip hybrid (*)			160	20	180	Pisa					Nov-08	Jan-08	Jan-09
GEM Pad hybrid (*)			520	60	580	Pisa					Nov-08	Jan-08	Jan-09
Horseshoe Card			40	5	45	Pisa					Nov-08	Jan-08	Nov-08
11th Card			4	2	6	Pisa					Oct-08	Jan-08	Nov-08
Kaptons between Horseshoe & 11th			40	7	47	Pisa							
			40	7	47								
			40	7	47								
H,P,T card (sensor carrier)			4	2	6	Pisa							Dec-08
Opto TX			8	2	10	Pisa					Oct-08	Jan-08	Nov-08
Trigger cards													
TriggerTimingControl Card (TTCci)	1			4	5	CMS							
Local Trigger Control Card (LTC)	1			1	2	CMS							
Coincidence Chip hybrid	48		52	20	120	Hungary					Oct-08	Mar-08	Jan-09
VFAT Trigger mezzanine	24		8	6	38	CERN					Oct-08	Mar-08	Dec-08
Repeater Card	124			12	136	CERN			Nov-08	Nov-08			Jan-09
Optocoupler card	2			1	3	CERN			Nov-08	Nov-08			Jan-09
Trigger output card	1			1	2	Pisa							Dec-08
T1 Trigger Merger Mezzanine		2		1	3	Genova							Jun-09
DAQ Cards													
Gigabit Opto Hybrid (GOH)	120	100	72	53	345	CMS							
OptoRX	12	10	10	9	41	Preshower							Nov-08
VME64x Host Board	6	4	4	6	20	CERN							
VME Back Plane	4			1	5	Bari							Nov-08
Slink64 card	8	6	4		18	CMS							
Control Cards													
CCUM (CCU mezzanine)	24	40	20	16	100	CMS							
CCUM Carrier		4	4		8						Jan-09	Jan-09	Jan-09
DOHM (DOH on it available)	4	4	4	2	14	CERN							Nov-08
FEC	1	1	1	1	4	CMS							
FEC mezzanine	4	4	4	2	14	CMS							
ELMB					20	CERN Pool							
ELMB Motherboard					16	CERN Pool							
ELMB DAC (Radmon readout)	8	3	2	3	16	CERN/LHCb							
Patch Panel board (Radmon readout)	8	3	2	3	16	CERN/LHCb						Nov-08	Dec-08
Radmon integrated sensor carrier	24	8	4		36	CERN DT							
Interlock card				2	2	CERN							Feb-09
Test cards (TTP needed in larger quantity for development)													
Horseshoe adapter card				2	2	Pisa							
Horseshoe prod test card				1	1	Pisa							
HOST board test setup				2	2	Preshower							
OptoRX test setup				2	2	Preshower							
TOTEM Test Platform (TTP)				20	20	CERN							

(*) The GEM strip hybrid and T1 hybrids are identical, for the cathodes the wire bonding is different if only the digital part of the VFAT is used. The GEM pad hybrid is only slightly different to match the channel to trigger sector correspondence.

Trigger and Data Acquisition

The DAQ and Trigger functions and algorithms are being developed as an mixture of software and firmware components. To make sure that they integrate smoothly and meet the performance needed for TOTEM-specific runs, and to take into account by design the interoperability of TOTEM with CMS, a unified requirement and specification procedure has been set up.

Wherever possible in the software (like in the case of the FEC and TTC subsystems) TOTEM is re-using libraries and/or applications inherited from CMS, with additions and specific modifications. New software packages have been built to deal with specific TOTEM hardware (i.e. the TOTFED VME board).

VME crates have been installed in the underground counting room at IP5. The related front-end PCs are now connected and operational. Dedicated tools for detector testing and commissioning have been developed, with innovative solutions like LOCAL DAQ systems running out of virtual machines, easily re-distributable in the collaboration.

Procurement of the full set of event-builder computers and storage for LOCAL DAQ is complete. The cluster is presently under test, running an emulated DAQ system. Speed and reliability of the storage system are being assessed. LOCAL DAQ components are used at IP5 for detector commissioning.

The trigger system is based on the VFAT Sbit outputs. 8 bits from each VFAT are programmed to map a group of input with a fast OR output. The trigger hits defined here will be used to elaborate a raw tracking algorithm to be used for the trigger of the experiment. The RP and T2 detectors use an onboard trigger chip (CC) to perform a majority coincidence of the hits recorded between different planes of the detectors. T1 has a more complex geometry requiring a different approach for the tracking.

The trigger tracks from RP and T2 are sent to the counting room through optical links or electrical LVDS links for the 220m RP, while T1 send hits with the same hardware. Totem trigger in the counting room is using the same hardware of DAQ to simplify the design, but special algorithms are being developed for the local FPGAs.

The algorithms foreseen are based on combinatorial logic built with Look Up tables, requiring track counting and grouping on each detector. The information from each subdetector is combined in a special mezzanine card developed in Siena, that deliver the trigger information to the TTC system and in case of combined runs with CMS, provides the necessary information for a CMS/TOTEM trigger.

Installation and Commissioning

It is foreseen that almost all TOTEM detectors will be installed before the end of the Winter shutdown. The required installation of cables, gas pipes, cooling and interlock systems is underway.

The installation of the detectors and related electronics in the Roman Pots in the tunnel needs about 1 day per detector package and should be done in the shadow of the work needed by the machine. Movements and cooling tests are foreseen as well as interlock studies.

The installation of the T1 and T2 telescopes has to be organised in close collaboration with CMS, respecting their installation schedules. Some open issues about the mechanical support structure have to be discussed and solved.

The TOTEM readout and trigger system, in a stand-alone mode, will be installed in IP5 rather soon to allow extensive commissioning of all detector parts. This includes also the important Detector Control Systems (DCS) and general counting room infrastructure.

Offline Software and Computing

The TOTEM Offline Software, which includes simulation, reconstruction, calibration, alignment and analysis, is based on the CMSSW Framework. Due to the modular structure of the CMS software, the TOTEM related packages can be incorporated in it, allowing in the future a combined TOTEM/CMS detector simulation and analysis. The first release of the TOTEM Offline Software has been issued during summer 2008.

A more complete release is foreseen for the end of year 2008. It will include optimisation of the reconstruction algorithms and a preliminary simulation of the L1 Trigger response. At the beginning of 2009, there will be a production of simulated data based on this release. We will continue the development of analysis tools to facilitate data and physics analysis. The (track) reconstruction algorithms have been already tested, when available, with test beam data. The Calibration and Alignment chain, using the Conditions Database, needs to be developed. In 2009 the review and optimisation of the software will continue, following the commissioning of the detectors.

Physics

The early LHC runs will be at low β^* with beams having reduced number of bunches and a lower number of protons per bunch giving TOTEM ample opportunities to make its first physics studies: high-|t| elastic scattering, high mass central and single diffraction and forward charged particle production in inelastic events. In addition, TOTEM is preparing for the possibility of shorter β^* = 90 m runs aiming at an early total cross section measurement with 4-5 % relative precision as well as studies of soft diffraction at any diffractive mass value.

The physics group is preparing for analysis of TOTEM data from these runs in close collaboration with the offline software group. The offline software group is currently preparing the first release of the full TOTEM offline simulation and reconstruction chain by the end of the year. After a first large MC production during January 2009 of elastic and inelastic events at β^* = 2 m, the time up to the LHC start will be devoted to developing efficient trigger selection criteria for the low β^* physics as well as preparing an analysis framework and different analysis tools (e.g. selection of proton candidates from Roman Pots and charged particle candidates from the T1 and T2 telescopes) for the physics analysis of the first data. Meanwhile, the group pursues systematic comparisons of different event generators, especially for the forward charged particle production in inelastic events. A detailed MC study of beam induced proton background in the Roman Pot detectors is also ongoing. Both studies are made in view of preparing for what could be expected to be seen in the first data.

Collaboration

During this summer, the TOTEM Collaboration has welcomed as a new collaborator a group under the leadership of Prof. Tamas Csörgo from the Hungarian institute MTA KFKI RMKI. With its three active members, this new collaboration was fast integrated into TOTEM. The participation on the construction funds of 80 kCHF was used for the Silicon detector read-out, as agreed by the TOTEM Collaboration Board. They also contribute in the usual way to the M&O funds.

Table 5: TOTEM Financial matrix

TOTEM - 12/09/2008 - Financial Matrix

TOTEM	TOTAL			CERN			INFN			Finland			Brunel			Estonia			Prague			NSF			Hungary			C.Projects		
	MoU	Proj	Paid	MoU	Proj	Paid	MoU	Proj	Paid	MoU	Proj	Paid	MoU	Proj	Paid	MoU	Proj	Paid	MoU	Proj	Paid	MoU	Proj	Paid	MoU	Proj	Paid	MoU	In	Out
1. ROMAN POTS	**2476**	**3226**	**2970**	*1702*	*2450*	*2336*																								
1.1 Roman Pot mechanics	651	865	845	456	618	598													195	247	247									
1.2 Movement	204	243	243	204	243	243																								
1.3 Beam position monitor	171	122	122	169	120	120													2	2	2									
1.4 Detector mechanics	133	175	160	133	175	160																								
1.5 Silicon sensors	228	299	299	110	236	299							55	0	0							63	63	0						
1.6 Cooling	209	310	219	209	310	219																								
1.7 Electronics	554	643	562	175	260	258										40	42	42				324	244	165	0	80	80	15	17	17
1.8 Power supplies and cables*	287	459	429	206	378	348	48	48	48	13	13	13				2	2	2	5	5	5	13	13	13						
1.9 Miscellaneous	40	110	91	40	110	91																								
2. T1-CSC	**1820**	**1742**	**1706**	*441*	*361*	*324*																								
2.1 70 CSC Detectors	627	640	640				627	640	640																					
2.2 Electronics	666	567	566	73	66	65	509	416	416													70	70	70				15	15	15
2.3 Power supplies and cables	159	201	201	119	81	81	40	120	120																					
2.4 Supports and services	369	334	299	249	214	178	50	50	50																			70	70	71
3. T2-GEM	**1303**	**1521**	**1414**																											
3.1 50 GEM Detectors	434	515	471							434	515	471																		
3.2 Electronics	533	570	560				518	555	546																			15	15	14
3.3 Power supplies and cables	138	172	167				138	172	167																					
3.4 Supports and services	199	264	216							90	155	106																109	109	110
4. TEST SETUP	**150**	**150**	**150**																											
4.1 Cables, power supplies & infrastr.	40	40	40																									40	40	40
4.2 Electronics DAQ and computing	70	70	70																									70	70	70
4.3 Pool rental & Consumables	40	40	40																									40	40	40
5. DAQ EVENT BUILDER	**720**	**723**	**222**																											
5.1 Readout column	170	137	137				170	137	137																					
5.2 Link into CMS DAQ**	500	500	0																											
5.3 Online PC & storage	50	86	85				33	69	69																			17	17	16
TOTAL TOTEM	**6470**	**7362**	**6462**	**2142**	**2811**	**2660**	**2133**	**2207**	**2193**	**537**	**683**	**590**	**55**	**0**	**0**	**42**	**44**	**44**	**202**	**254**	**254**	**470**	**390**	**248**	**0**	**80**	**80**	**390**	**393**	**393**

* Item 1.8 includes the redistributed Polish funds. The status of the compensation funds for those 127k is shown in the Credits sheet.

** Item 5.2 is foreseen for linking to CMS DAQ. It is not included in current CERN MoU and Projection columns, but it is included in the TOTAL MoU and Projection columns.

Construction Budget

Table 5 summarizes the costs of the construction budget as stated in the original MoU together with the new projections and the contributions of the collaborating institutes. The contribution of the new Hungarian institute (80 kCHF) is foreseen for the RP electronics and reduces the load on NSF. The account for the Common Projects is balanced and will be closed now.

Some expenses could not be foreseen at the time of the MoU. For the final completion of the TOTEM detector, stringent safety and interlock systems connected to the LHC and some absolutely necessary improvements of the experiment's infrastructure are mandatory. These additional expenses of about 460 kCHF should be covered by CERN either because they are related to the CERN involvements (according to the MOU) or to the role of CERN as the host laboratory.