

## Financial Plan for CMS Upgrade

In the last RRB meeting of October 2011 CMS described progress with preparations and the execution of some work defined in the Technical Proposal for the Upgrades, covering all projects considered necessary to maintain and increase, the physics potential of the experiment for operation at  $1\text{-}2 \times 10^{34} \text{cm}^{-2}\text{s}^{-1}$  (Phase I of the Upgrades).

Phase II of the Upgrades will cover all projects needed for CMS be able to cope with the high luminosity running of LHC, (luminosity leveling at  $4\text{-}5 \times 10^{34} \text{cm}^{-2}\text{s}^{-1}$ ). The high luminosity running of LHC is expected to enter into operation as of the year 2020. The preparations for the second phase of the Upgrades, will require R&D, which has to be conducted in parallel with data-taking and with the construction and installation work necessary for Phase I.

Table 1 below summarizes our current understanding of the costs of the first phase of the Upgrade. Details of the project and of the estimated costs for Phase I can be found in the document Technical Proposal for the Upgrade of the CMS detector through 2020 (CERN-LHCC-2011-006) submitted to the LHCC.

**Table 1: Upgrade Phase I Costs (kCHF)**

<b>Subsystem/Common Item</b>	<b>Budget</b>
	<b>k CHF</b>
<b>Pixel Tracker</b>	<b>17,350</b>
<b>HCAL</b>	<b>5,817</b>
<b>HF - Phototubes</b>	<b>1,990</b>
<b>Muon CSC</b>	<b>5,570</b>
<b>Muon DT</b>	<b>2,200</b>
<b>Muon RPC</b>	<b>4,220</b>
<b>DAQ</b>	<b>6,700</b>
<b>Trigger</b>	<b>4,600</b>
<b>Common Items</b>	
Magnet power and cryo	1,330
Beam Instrumentation	1,540
Infrastructure	6,315
Test Beam Facilities Upgrade	610
Safety systems upgrade	964
Electronics Integration	1,575
Engineering Integration	3,666
<b>Grand Total</b>	<b>64,447</b>
<b>10% of which, Common Fund</b>	<b>6,445</b>

As proposed at the October 2010 RRB Meeting, a 10% fraction of the Upgrade cost would be collected in cash into an Upgrade Common Fund to cover the most urgent Common Items.

Discussions have been steadily progressing with Funding Agencies since the beginning of 2011 to prepare a global cost-sharing matrix for the Upgrade Phase I. The target is to obtain commitments from each country equal or higher with respect to their fraction of PhDs in CMS. The construction budget for the Upgrade Phase I covers the period 2011-2017.

At this April 2012 RRB meeting we present the latest status of the cost-sharing matrix for the Upgrade Phase I (Table 2).

These costs are without any contingency and are based on the estimates made at the time the Technical Proposal for Upgrades was finalized in 2010. CMS understands that each Funding Agency has its own process and timetable for reaching a final decision on the Upgrade, therefore the actual numbers vary from firm commitments, based on approved funding, through proposals incorporated into national plans but not yet funded, to expectations for funding that are still at an early stage of discussion.

CMS appreciates the efforts of Funding Agencies to provide information concerning their commitments and allowing the completion of the Upgrade Cost-sharing Matrix. We appeal to those who have not done so yet to provide these figures as soon as their national budgetary approval process allows.

The most urgent need is for funds to carry out work on Common Items in Long Shutdown 1 (LS 1), due to start in November 2012. This constitutes, to a large extent, consolidation work on the CMS detector, necessary to allow Subsystem Upgrades to take place. The LHCC expressed strong support for this need following its meeting with CMS on 20 March and confirmed that the Upgrade Common Items are critical to the future success of the whole Phase I Project.

These costs are expected to be financed either from direct contributions from FAs to specific Common Items or from the Upgrades Common Fund (CF). The Upgrades CF is foreseen to cover the most urgent common upgrade-related needs for which there are no resources available due to insufficient contributions for specific Common Items. Since the Upgrades CF covers only 40% of the total costs of Common Items and the remainder is only partly covered by pledges from a few Funding Agencies, targeted contributions to concrete Common Projects are also required. Examples of such specific projects are as follows: Beampipe replacement, Radio Protection shielding, Magnet Cryo and Electrical Consolidation, Cooling Systems (busbars, racks, YE3) or Beam Monitoring.

Following discussions, which have taken place with Funding Agencies since the April 2011 RRB, about half of them have already paid or are in the process of paying their contribution to the Upgrades CF. This is very important to enable progress with the Upgrades Phase I as many items needed to be purchased or installed already in 2011 and in the course of this year, well in advance of other projects.

Some Subsystem Upgrade Projects are already in a relatively advanced state and were able to progress thanks to contributions from participating institutions. Some funding was also available for items initially foreseen as part of the CMS Upscope and subsequently included in the overall scope of the Phase I Upgrade. The most advanced Sub-detector projects are the HF Phototubes and the Muons (CSC, DT, RPC). A major part of the related work is expected to take place during LS 1 in 2012 - 2014. Other projects such as the Pixel Tracker, HCAL and Trigger are still in the phase of elaborating their Technical Design Reports (TDRs). The completion of the TDRs is expected in the course of 2012. Once finalized, the TDRs will allow a more precise evaluation of costs as compared to the estimates made in the Technical Proposal.

We deeply thank the Funding Agencies for their interest towards the projects proposed in the Technical Proposal for the Upgrades of CMS and for their continuing support. Special thanks are extended to those Funding Agencies who have already made cash contributions to the Upgrades Common Fund.

Table 2: Upgrade Phase I Preliminary Cost Sharing Money Matrix

3.04.2012		Subdetector-specific Upgrades						Detector-wide items													
								TDAQ		Common Items											
Institute FA	PhD %	Pixel Tracker	HCAL	HF - Phototubes	Muon CSC	Muon DT	Muon RPC	DAQ	Trigger	Magnet power and cryo	Beam Instrumentation	Infrastructure	Test Beam Facilities Upgrade	Safety systems upgrade	Electronics Integration	Engineering Integration	Total expected (projects)	Common Fund (CF)	Total Upgrade Due (incl. CF)		
		17,350,000	5,817,000	1,990,000	5,570,000	2,200,000	4,220,000	6,700,000	4,600,000	1,330,000	1,540,000	6,315,000	610,000	964,000	1,575,000	3,666,000					
Common Fund										535,741	620,331	2,543,761	245,716	388,311	634,430	1,476,711		6,445,000			
Austria	1.6%	68,846							1,200,000								1,268,846	102,154	1,021,494		
Belgium-FNRS	1.2%						236,000										236,000	74,294	742,905		
Belgium-FWO	1.2%						270,000										270,000	74,294	742,905		
Brazil	1.2%																0	78,937	789,336		
Bulgaria	0.6%																0	37,147	371,452		
CERN	5.8%	3,000,000					500,000	3,500,000			500,000	1,500,000		500,000		1,000,000	10,500,000	371,470	3,714,524		
China	0.7%				200,000		500,000										700,000	46,434	464,316		
Colombia	0.2%						10,000										10,000	13,930	139,295		
Croatia	0.5%							200,000									200,000	32,504	325,021		
Cyprus	0.4%	11,500							11,500								23,000	23,217	232,158		
Egypt	0.2%						150,000										150,000	13,930	139,295		
Estonia	0.3%					167,153											167,153	18,573	185,726		
Finland	1.0%	420,000					130,000						35,000				585,000	65,007	650,042		
France-CEA	1.1%																0	69,651	696,473		
France-IN2P3	3.8%	600,000						350,000	600,000				100,000		100,000		1,750,000	246,099	2,460,872		
Germany-BMBF	4.5%	1,600,000				612,000											2,212,000	287,889	2,878,756		
Germany-DESY	2.8%	1,200,000	XXXXXXXX														1,200,000	181,091	1,810,831		
Greece	1.1%							XXXXXX	1,000,000								1,000,000	69,651	696,473		
Hungary	0.7%		XXXXXXXX			XXXXXX											0	46,434	464,316		
India	2.1%		495,000				720,000										1,215,000	134,658	1,346,515		
Iran	0.4%	50,000															50,000	27,860	278,589		
Ireland	0.0%								XXXXXXX								0	0	0		
Italy	12.5%	1,400,000				1,000,000	350,000										2,750,000	803,303	8,032,659		
Korea	1.5%						400,000										400,000	97,511	975,063		
Mexico	0.8%																0	51,077	510,747		
New Zealand	0.1%																0	9,287	92,863		
Pakistan	0.1%					345,000						800,000					1,145,000	9,287	92,863		
Poland	1.1%																0	69,651	696,473		
Portugal	0.5%								500,000								500,000	32,504	325,021		
RDMS - DMS	1.5%		400,000		500,000												900,000	97,511	975,063		
RDMS - Russia	4.4%		1,400,000		1,300,000												2,700,000	283,246	2,832,325		
Serbia	0.2%																0	13,930	139,295		
Spain	3.5%					400,000											400,000	227,525	2,275,146		
Switzerland (ETHZ,PSI,UNIV)*	2.7%	3,800,000															3,800,000	176,448	1,764,398		
Taipei	1.1%	1,000,000															1,000,000	69,651	696,473		
Turkey	1.3%		380,000	0													380,000	83,581	835,768		
United Kingdom	4.0%	500,000						250,000	1,500,000			126,000			126,000		2,502,000	260,029	2,600,167		
USA (DOE-HEP, NSF)	31.7%	4,500,000	5,817,000	2,000,000	5,570,000			700,000	3,000,000								21,587,000	2,046,032	20,459,365		
USA (DOE-NP)	1.6%																0	102,302	1,022,968		
Grand Total	100.0%	18,150,346	8,492,000	2,000,000	7,570,000	2,179,153	3,611,000	5,000,000	7,811,500	535,741	1,120,331	4,969,761	380,716	888,311	860,430	2,476,711	59,600,999	6,445,000	64,447,000		

The figures presented in this table are a combination of funding situations ranging from assumed/estimated contributions and requests for funds to firm pledges