

## CMS Global Financial Plan

Upon the recommendation of the CERN management CMS has prepared a global financial plan up to 2010 evaluating not only the shortfall for the low luminosity detector, but also the funds needed to introduce the staged items for the design luminosity ( $10^{34} \text{ cm}^{-2}\text{s}^{-1}$ ).

This document presents the global financial plan covering the completion of the low-luminosity and design-luminosity CMS detector. The items under consideration in this global plan are also presented in a prioritized way.

### 1. Background

**All the information presented in this document has previously been presented in preceding RRBs.** This document brings all this information together in one place.

A financial plan was presented to the April 2005 Resources Review Board (RRB20) [CERN-RRB-2005-015], requesting extra resources at the level of  $\sim 32$  MCHF to complete the low luminosity detector. This plan was based on the expectation that Russia would contribute 7,000 endcap crystals *in-kind*. At the April 2006 RRB22 [CERN-RRB-2006-064] it was announced that Russia will contribute, *in-kind*, only 1,500 endcap crystals. Consequently a new order for 5,500 crystals is now being negotiated.

In the April 2005 RRB20 [CERN-RRB-2005-015], it was also stated that 10 out of the 13 MCHF deficit from the 2002 Cost to Completion exercise [CERN-RRB-2002-010] could be covered by staging or internal contingency. It has turned out that only around 8 MCHF out of the 10 MCHF could be so covered leaving an extra shortfall of 2 MCHF.

As a result, and including the requests made in April 2005 [CERN-RRB-2005-015] that have not yet been covered by firm pledges, we estimate that there is a shortfall of 17.5 MCHF to cover the crystals and the common projects for the low luminosity detector (items 1.1, 1.2 and 1.3 Table 1).

The situation with respect to the construction of the staged items for design luminosity operation has not changed since 2002 [CERN-RRB-2002-010] except that now 6 DAQ slices (instead of 4) out of 8 are staged. The DAQ implementation plan foresees starting with 2 DAQ slices in 2007, adding 2 more in 2008, another 2 in 2009 and the remaining 2 in 2010. The last 2 slices will be restored using funds already foreseen in M&O Cat. A, as previously agreed. Each DAQ slice costs 2 MCHF. The total needed to restore the full DAQ is 8.4 MCHF (items 2.1 and 2.2 Table 1)

The cost estimate of the other staged items is estimated to amount to 16.6 MCHF (items 3.1, 3.2 and 3.3 Table 1). All these items have been presented in earlier RRBs.

In summary, together with the 17.5 MCHF missing for the low luminosity detector, the 8.4 MCHF to restore the DAQ and the 16.6 MCHF for the non *in-kind* staged items, we arrive at a total of 42.5 MCHF needed to complete the design luminosity detector (Table 1).

The responsibility for the upgrade of the forward RPC system has been taken by China, India, Iran, Korea and Pakistan. The groups from these countries have either made, or are preparing to make, the appropriate requests to their Funding Agencies. We shall consider this contribution as being *in-kind* and value it at 5.9 MCHF. This *in-kind* contribution is not included in the 42.5 MCHF

## 2. Prioritization

The first priority is to complete the low luminosity CMS detector (17.5 MCHF).

The second priority is to restore the full DAQ capability (8.4 MCHF).

The third priority is to upgrade to the design-luminosity detector (16.6 MCHF). The exact details will be determined after the examination of first data.

**Table 1: Shortfall 2008, Restore the full DAQ and Upgrade to Design Luminosity (kCHF)**

The contribution to the upgrade of the RPC system is considered to be *in-kind* and is not included here. Its value is estimated to be 5.9 MCHF.

<b>1.0 Shortfall 2008 Detector</b>	<b>17,530</b>
1.1 Shortfall Crystals	14,000
1.2 Shortfall Common Fund	2,035
1.3 Shortfall C&I	1,495
<b>2.0 Restore the full DAQ</b>	<b>8,400</b>
2.1 DAQ (4 slices)	8,000
2.2 Extra Infrastructure for DAQ	400
<b>3.0 Upgrade to Design Luminosity</b>	<b>16,600</b>
3.1 Third forward pixel layer	2,500
3.2 Complete Endcap CSCs	10,700
3.2.1 ME4/2 mech. and electronics	9,200
3.2.2 Restore ME1/1a electronics	1,500
3.3 Infrastructure, C&I	3,400
3.3.1 YE4	1,400
3.3.2 Extra installation costs	1,000
3.3.3 Extra neutron shielding	1,000
<b>Total</b>	<b>42,530</b>

### 3. A Financial Plan in 3 steps

Table 2 summarizes the funding situation: in 2002 the funding was 450 MCHF (column 2). In October 2002 (RRB15) there was a first cost to completion request (CTC1) of ~63 MCHF. CMS obtained firm promises for 52.1 MCHF (Column 3). In April 2005 there was a second Cost to Completion exercise (CTC2). CMS requested ~32 MCHF and obtained promises for 21.6 MCHF (Column 4). The total funding for construction guaranteed so far is given in column 5, which is the sum of the previous 3 columns. The shortfalls in CTC1 and CTC2 add up to ~21 MCHF. This is not far from the sum CMS needs to complete the low luminosity detector and to restore the full DAQ capability (8 slices).

As far as M&O Cat A costs are concerned CMS has revised its costs and projections. The net effect is a reduction of 14 MCHF, integrated up to 2010, compared to projections made in 2002. Some 8 MCHF have already been achieved.

**Table 2: Completing the Design Luminosity CMS detector in three steps (kCHF).**

	PhDs	MoU Funding 2002	CTC1 RRB15 Oct02	CTC2 RRB20 Apr05	Constr. Funding 2006	STEP 1 Low Lumi (Constr.)	STEP 2 DAQ (PhD)	STEP 3 Rest (PhD)	Total Design Lumi
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Austria	11	3,900	600	275	4,775	211	45	171	427
Belgium	27	5,000	870	300	6,170	272	111	420	803
Brazil	9				0	0	37	140	177
Bulgaria	5	600	0	0	600	26	21	78	125
CERN	72	85,200	13,500	4,800	103,500	4,569	297	1,119	5,984
China	13	4,315	500	300	5,115			<i>in kind RPC</i>	
Croatia	7	280	49	20	349	15	29	109	153
Cyprus	3	600	106	0	706	31	12	47	90
Estonia	2	90	16	6	112	5	8	31	44
Finland	12	5,000	870	300	6,170	272	49	187	508
France CEA	14	5,600	1,687	445	7,732	341	58	218	617
France IN2P3	38	19,700	2,000	2,000	23,700		2,000	0	2,000 <i>Pledged</i>
Germany BMBF	41	17,000	2,709	1,100	20,809	919	169	637	1,725
Germany DESY	5				0	0	2,000	0	2,000 <i>New Collab.</i>
Greece	17	5,000		0	5,000	221	70	264	555
Hungary	6	1,000	58	0	1,058	47	25	93	165
India	26	4,400	300	500	5,200			<i>in kind RPC</i>	
Iran	3	510	700	0	1,210			<i>in kind RPC</i>	
Ireland	1				0	0	4	16	20
Italy	181	55,000	8,927	4,000	67,927	2,998	746	2,813	6,557
Korea	12	1,315	500	147	1,962			<i>in kind RPC</i>	
Mexico	5				0	0	21	78	98
New Zealand	3				0	0	12	47	59
Pakistan	3	2,445	230	149	2,824			<i>in kind RPC</i>	
Poland	12	3,000		0	3,000	132	49	187	368
Portugal	5	2,000	300	140	2,440	108	21	78	206
RDMS	72	18,862	2,211	1,657	22,730	1,003	297	1,119	2,419
Serbia	3		450	0	450	20	12	47	79
Spain	34	6,000	1,350	450	7,800	344	140	528	1,013
Switzerland	30	86,500		200	86,700	0	124	466	590
Taipei	11	2,330	410	0	2,740	121	45	171	337
Turkey	18	1,000	58	0	1,058	47	74	280	401
UK	49	9,100	918	3,000	13,018	575	202	762	1,538
USA	418	104,320	12,800	1,868	118,988	5,252	1,722	6,497	13,471
<b>Sum</b>	<b>1,168</b>	<b>450,067</b>	<b>52,119</b>	<b>21,657</b>	<b>523,843</b>	<b>17,530</b>	<b>8,400</b>	<b>16,600</b>	<b>42,530</b>
<b>Requested</b>			<b>63,000</b>	<b>32,000</b>					

Table 2 also shows also how we propose to complete the design luminosity detector in three steps.

The first priority is to complete the low luminosity detector (Step 1, column 6). For this 17.5 MCHF must be committed in 2007 and urgent action is required. Column 6 shows how we propose to share the needed 17.5 MCHF. The already pledged contributions of 2 MCHF by France IN2P3 and of 2 MCHF by Germany DESY (New Collaborator) are

reserved for the DAQ restoration (Column 7). Therefore IN2P3 and DESY are not requested to contribute in column 6. Likewise the Funding Agencies interested in the upgrade of the endcap RPC system (China, India, Iran, Korea and Pakistan) are not asked to contribute. Finally Switzerland is not requested to contribute, because of its exceptional initial investment to the construction of core items (86.5 MCHF) and to the Engineering Integration Center (EIC, 4.5 MCHF). The sharing is done between the rest of the Funding Agencies pro-rata their present contributions to the construction as shown in column 5. *The completion of the low luminosity detector is shared by the Funding Agencies in proportion of their initial investment.*

The second priority is to complete the DAQ (Step 2, column 7). For this 8.4 MCHF are needed in addition to cover 4 DAQ slices in steps of 2 MCHF and 0.4 MCHF for extra infrastructure. We note that 2 DAQ slices are already pledged by IN2P3 and DESY. We propose to share the rest of the needed money (4.4 MCHF) between all the other Funding Agencies pro-rata the number of PhD scientists, as for the M&O Cat A budget. The number of PhD physicists per Funding Agency used for the sharing is listed in column 1. It is the list used for the sharing of the 2007 M&O Cat A budget. There is good hope that a third DAQ slice can be covered by the US Heavy Ion community. This would cover the US contribution for DAQ restoration in Step 2.

The third priority is to upgrade to design-luminosity detector (Step 3 column 8). The total sum needed is 16.6 MCHF (items 3.1, 3.2 and 3.3 Table 1). The Funding Agencies involved in the endcap RPC completion are excluded. The rest of the Funding Agencies (except IN2P3 and DESY) are invited to contribute as for the DAQ in proportion of their PhD physicists. This last step will depend in details after examination of the first data.

The last column (column 9, sum of the previous 3 Steps) summarizes for all funding agencies their total new requested contribution to complete CMS to design luminosity (42.5 MCHF in total).

#### **4. Upgrade of the Endcap RPC System**

The present endcap RPC system is a joint effort by Korea, Pakistan and China. Because of limited funding the system was descoped to three stations and rapidity coverage reduced to  $|\eta| < 1.6$ . The same group of countries plus two new countries (Iran and India) have expressed interest in upgrading the endcap RPC system to five stations and full rapidity coverage ( $|\eta| < 2.1$ ). This will provide a robust forward muon trigger system, for the operation at design luminosity.

Discussions have started on a preliminary money matrix shown in Table 3. We note that Pakistan has already firmly pledged 2.1 MCHF and that the discussions are well advanced in Korea, India and Iran. China is interested in collaborating with Korea on the construction of the small forward chambers RE1/1, RE2/1 and RE3/1 that will extend the rapidity coverage to 2.1.

**Table 3: Money Matrix in discussion for the upgrade of the Endcap RPC system (kCHF)**

	PhDs	Additional RE gaps	RE4/2, RE4/3	RE2a	RE1/1, RE2/1, RE3/1	Trigger	Sum
<b>Cost</b>		<b>1,000</b>	<b>1,300</b>	<b>1,300</b>	<b>1,300</b>	<b>1,000</b>	<b>5,900</b>
<b>China</b>	13				to be decided	to be decided	to be decided
<b>India</b>	26			700		200	900
<b>Iran</b>	3			600		200	800
<b>Korea</b>	12	1,000			800	200	2,000
<b>Pakistan</b>	3		1,300			200	1,500
<b>Funding</b>	<b>57</b>	<b>1,000</b>	<b>1,300</b>	<b>1,300</b>	<b>1,300</b>	<b>800</b>	<b>5,200</b>

The cost estimate of this *in-kind* project is 5.9 MCHF. It is not included in the 42.5 MCHF of table 2 (column 9).

## 5. Conclusions

CMS is indebted to the many Funding Agencies for their previous efforts to cover the additional costs incurred during the long construction period so far. The low luminosity detector completion is now approaching a successful end of construction.

Upon the recommendation of the CERN management CMS has prepared a global financial plan up to 2010 evaluating not only the shortfall for the low luminosity detector, but also the funds needed to introduce the staged items for the design luminosity of  $10^{34} \text{ cm}^{-2}\text{s}^{-1}$ .

**A plan in three steps is proposed.** The highest priority is given to the timely completion of the low-luminosity detector. In particular the order for 5,500 endcap crystals has to be placed and 3.5 MCHF have to be secured to cover the shortfall in the Common Fund and C&I.

All the Funding Agencies are kindly invited to reach a rapid agreement on the first step of 17.5 MCHF in order to finish the low luminosity detector in time for the first physics run in 2008. CERN and CMS Managements are ready to meet the Funding Agencies as required so as to reach an agreement well before the next RRB in April 2007.