15. INSTITUTIONAL RESPONSIBILITIES, COSTS AND SCHEDULE

15.1 SCHEDULE AND PLANNING

The HCAL project has a planning methodology embedded in the overall CMS planning. A summary of the CMS general planning is given in theTechnical Design Report for the Magnet Project [1]. A summary outline of CMS planning as regards HCAL, extracted from the general CMS planning, is shown in Fig. 15.1. This schedule refers to the experimental halls, the magnet, and the Muon, ECAL, and Tracking subsystems as well as HCAL. Since HB is supported off the cryostat vacuum tank, HE is supported off YE, and HB in turn supports ECAL and the Tracker, these subsystem milestones are also indicated in the summary.

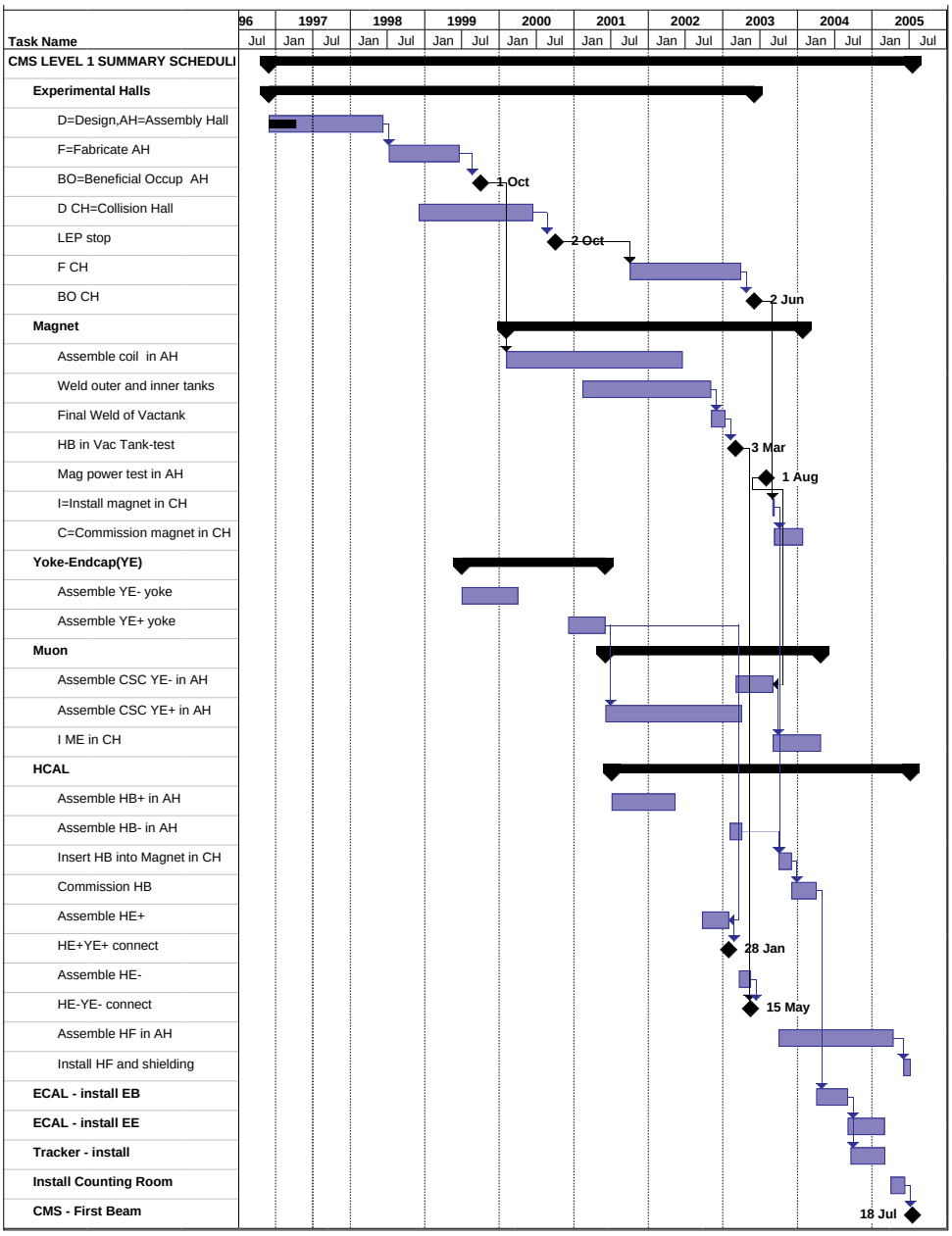

Fig. 15.1: CMS summary schedule relevant to HCAL.

The required schedule for HCAL which is needed to meet the level 1 schedule shown in Fig. 15.1 is given in Fig. 15.2 (a) and (b). Note that these milestones summarise the planning for HB, HO, HE and HF. The relevant level 1 schedule and the HB level 2 schedule are shown in Fig. 15.2 (a), while the HO, HE, and HF level 2 schedules appear in Fig. 15.2 (b). The HB, HO, HE, and HF activities are linked to the level 1 summary schedule, as shown in the figure. The planning which appears here must still be made consistent with the funding profiles of all the contributing HCAL institutions as they become known and understood. This task will begin with execution of the Memoranda of Understanding (MOU). The details of the level 2 schedule will undoubtedly require adaptation as more is understood about the funding profiles.

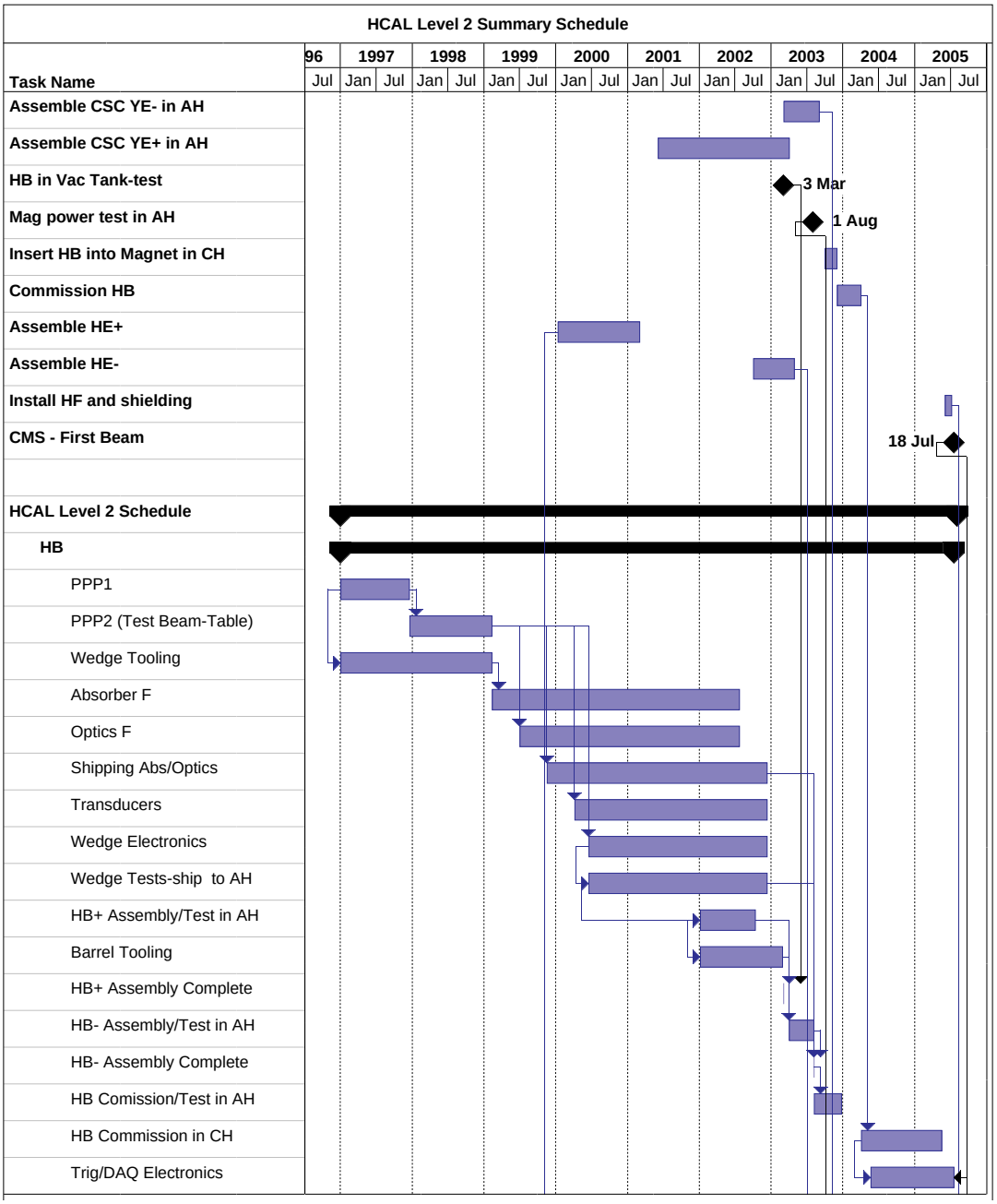

Fig. 15.2 (a): HCAL level 1 and HB level 2 summary schedule.

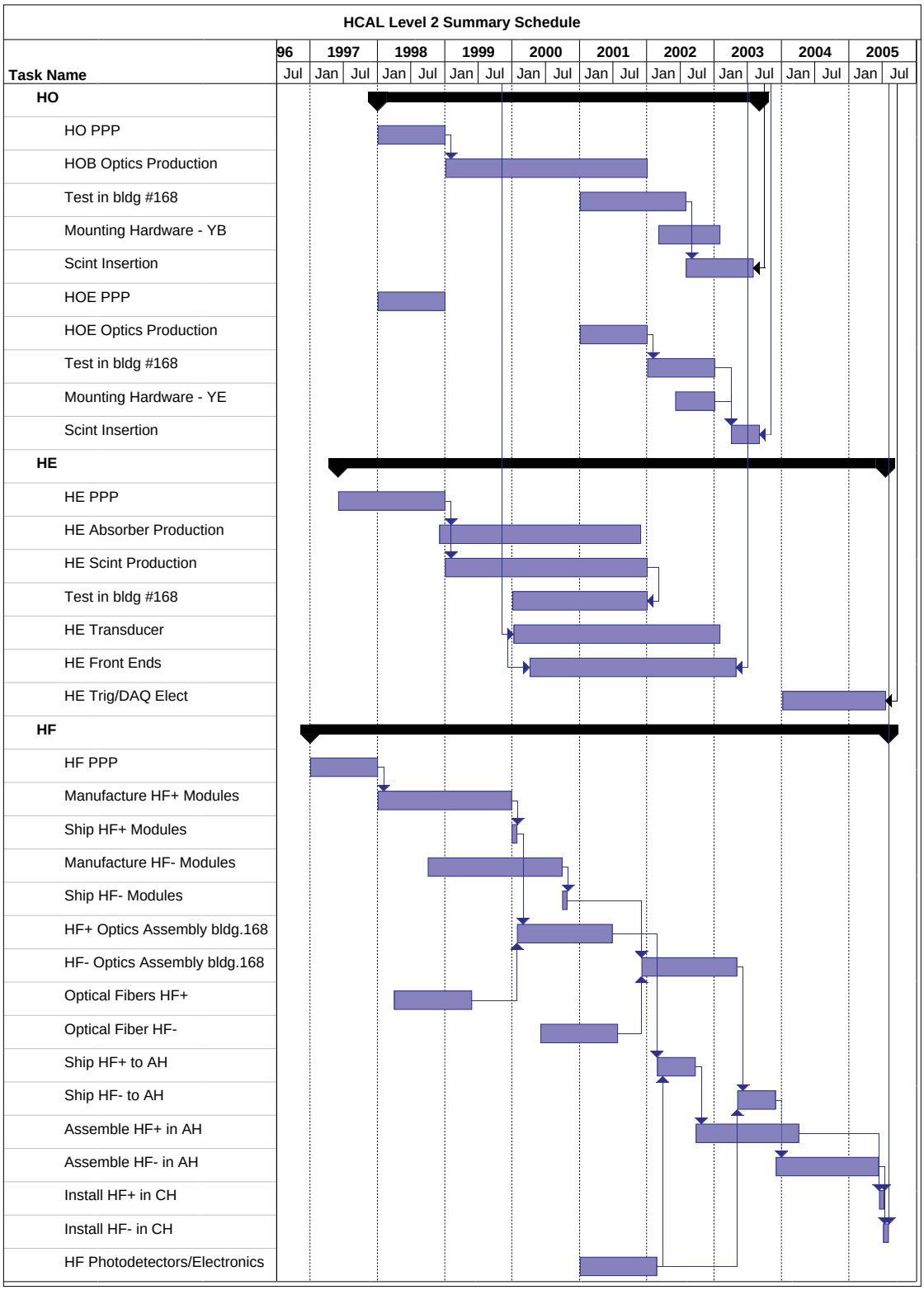

Fig. 15.2 (b): HO, HE, and HF level 2 summary schedule.

15.2 COST ESTIMATES

As is explained below, the cost estimates for HCAL are made in great detail. A summary is shown in Table 15.1. The HCAL costs are given using CERN accounting methods, and the full costing for HCAL is available in the CMS Cost Estimate Version 8 [2]. We reproduce here only a higher level rollup of the costing, suitable for a single page summary.

Table 15.1: Summary of the HCAL costs, in kCHF, from CMS Cost Book Version 8.

No.	Item	Total Cost
4	**Hadron Calorimeter**	44 498
4.1.1	**Barrel**	20 067
4.1.1.1	Mechanical Structure	8 469
4.1.1.2	Optical System	2 162
4.1.1.3	Phototransducers	2 694
4.1.1.4	Electronics	1 040
4.1.1.5	Tooling	3 767
4.1.1.6	Shipping	504
4.1.1.7	Prototypes (2 wedges)	1 430
4.1.2	**Outer Barrel**	3 827
4.1.2.1	Mechanical Structure	260
4.1.2.2	Optical System	2 118
4.1.2.3	Phototransducers	959
4.1.2.4	Electronics	490
4.2.1	**Endcap**	12 761
4.2.1.1	Mechanical Structure	7 163
4.2.1.2	Optical System	1 590
4.2.1.3	Phototransducers	2 333
4.2.1.4	Electronics	891
4.2.1.5	Tooling	260
4.2.1.6	Shipping (included in Mech. Structure)	
4.2.2	**Outer Endcap**	1 001
4.2.2.1	Mechanical Structure	26
4.2.2.2	Optical System	249
4.2.2.3	Phototransducers	481
4.2.2.4	Electronics	245
4.3.1	**Forward Electromagnetic Section**	1 974
4.3.1.1	Detectors and Components	1 360
4.3.1.2	Electronics	615
4.3.2	**Forward Hadronic Section**	3 415
4.3.2.1	Detectors and Components	2 800
4.3.2.2	Electronics	615
4.3.3	**Forward Tailcatcher**	1 119
4.3.3.1	Detectors and Components	947
4.3.3.2	Electronics	171
4.3.4	**Forward Common Systems**	334
4.3.4.1	Mechanical Structure and Support	65
4.3.4.2	Assembly/Installation	105
4.3.4.3	Calibration/Monitoring	111
4.3.4.4	Service Systems	53

15.3 COST PROFILE - TENTATIVE

A first attempt has been made to integrate the cost items shown in Table 15.1 with the level 2 schedule for HCAL. The resulting cost profile is shown in Fig. 15.3. This exercise has only begun. The full realisation of this planning exercise requires a good knowledge of the funding profile of the integrated total funds available from each of the countries participating in HCAL and the subsequent linking of the cost profile to the composite funding profile. This is a work in progress, and has just begun at this time.

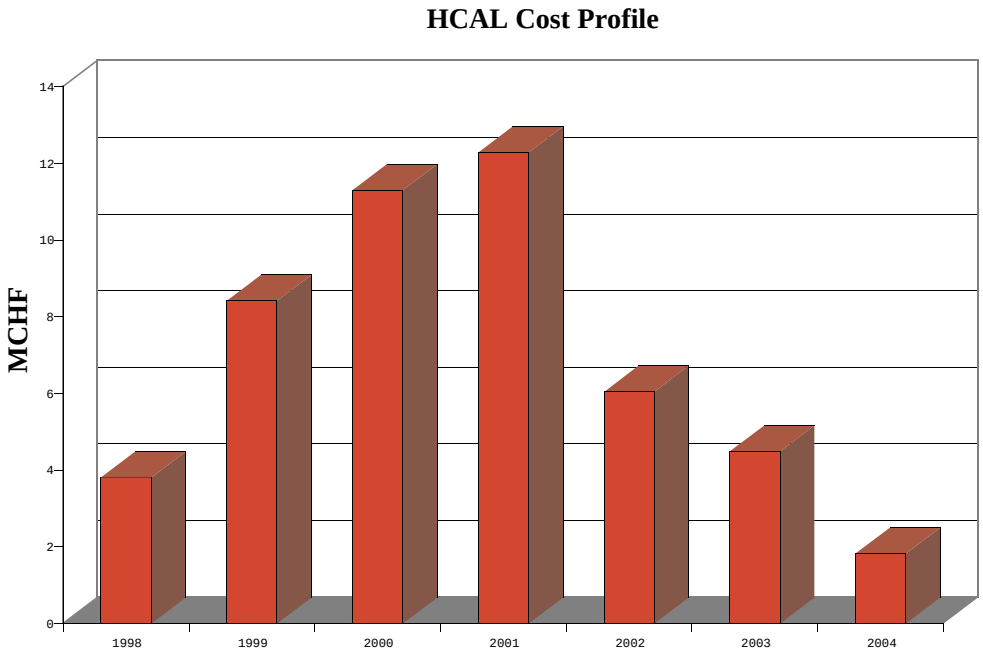

Fig. 15.3: Tentative HCAL Cost Profile.

15.4 MONEY MATRIX

There are several groups participating in the HCAL system. It is of paramount importance to first see if the resources thought to be available to these groups match the expected costs of the HCAL system. In Table 15.2 we give the HCAL "money matrix" showing the resources available to the groups participating in HCAL. Within the uncertainties attached to this table, there is a good match of costs and resources. Note that the design of HF has yet to be fully defined and that new groups may join that effort. Within the uncertainties and the flexibility allowed in the final definition of the scope, HCAL costs match the available funds. At this time it is premature to attempt to match the cost profile shown in Fig. 15.3 with the funding, even though the time integrated "money matrix" appears to be sufficient to cover the total HCAL costs, as estimated in Table 15.1.

Table 15.2: The financial resources, in MCHF, of groups participating in HCAL.

	China	Hungary	India	RDMS	Turkey	US DOE	US NSF	Total Income	Cost Estimate version 8
HCAL Income	**1.4**	**0.3**	**1.1**	**11.1**	**0.6**	**24.4**	**4.4**	**43.3**	**44.5**
HCAL Cost	**1.5**	**0.3**	**0.9**	**11.1**		**24.4**	**4.4**	**43.3**	**44.5**
Barrel	1.4		0.9			19.8	1.9	23.9	23.9
Endcap	0.1			9.1		1.4	2.5	13.2	13.8
Forward		0.3		2.0	0.6	3.2		6.1	6.8

There is the additional issue of the funding profile for the financial resources shown in Table 15.2. At present our knowledge of the funding profile is somewhat rudimentary. However, the US groups have been given a funding profile by their funding agencies. A first attempt to match costs and funds to schedule for the US groups in HCAL appears to indicate no major difficulties. This statement should be tempered by the fact that it is not yet clear if industrial firms involved in major purchases will require full payment at the start, or if a schedule of phased payments is possible, and if so the details of the obligation profile.

15.5 MANAGEMENT CONTROL

The HCAL project of CMS is headed by a project manager appointed by the CMS spokesperson with full consultation of the CMS collaboration. As explained in detail in the CMS Constitution [3], the HCAL project manager represents the HCAL system to the full CMS management as a member of the CMS Management Board. The organization of the HCAL effort is summarised in Fig. 15.4.

The groups participating in the HCAL project form the Institution Board of HCAL. All decisions are ratified by that board. The project has a single project manager and resource manager, who carry overall responsibility for the project. The geographic sectors, HB, HE and HF each have a project manager or coordinator and a technical coordinator. They report to the HCAL project manager. The HE Project manager is also a member of the CMS Management Board. The HB, HO, HE, and HF geographic sectors also have persons responsible for the engineering aspects of those sectors who report to their respective project coordinators.

There are a variety of tasks which apply to all subsystems. Indeed, the structure of this TDR reflects that fact, as does Fig. 15.4. The commonality of HCAL, for example electronics, is built into the structure of the HCAL project. Leaders for efforts common to HCAL are indicated in Fig. 15.4.

The overall governance of CMS is explained in the CMS Constitution [3]. The HCAL subsystem of CMS is governed in the same general fashion as are all CMS subsystems. In the HCAL case the three distinct geographic sectors (HB, HE, HF) are recognised as such, while the common efforts are also recognised and mirrored in the form shown in the HCAL organisation chart, Fig. 15.4.

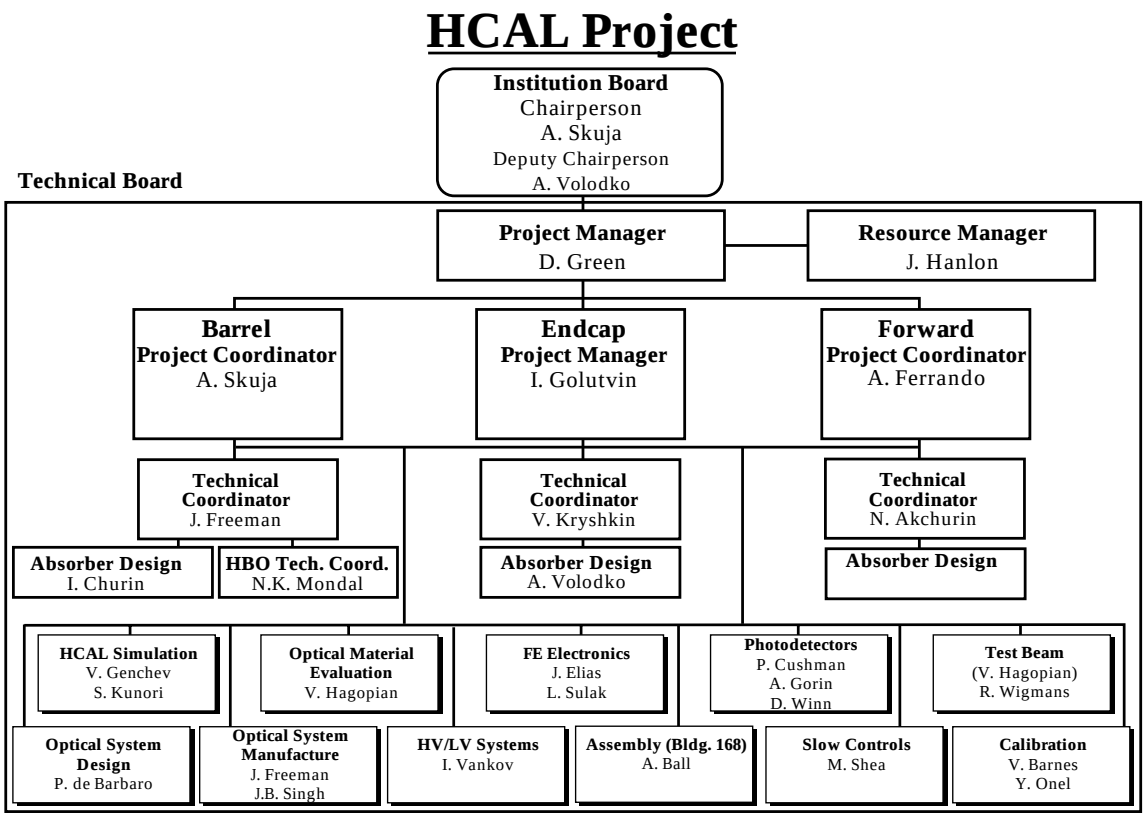

Fig. 15.4: The organisation chart of the CMS HCAL Project.

15.6 INSTITUTIONAL RESPONSIBILITIES

The tentative responsibilities of the countries involved in HCAL follow from the interests of the groups. Basically, the US groups are responsible for the HB mechanics and optics and for the electronics of all of HCAL. The RDMS groups are collectively working on the mechanics and optics of HE, while the combined Indian groups are responsible for the mechanics and optics of the samples made outside the solenoid in HB. A group of RDMS members, most notably ITEP, is responsible for the HF mechanical design and the absorber construction. The Hungarian and Turkish groups take the lead in the mechanical assembly of the HF quartz fibre active elements, while the US groups will supply transducers and front end electronics for HF. Of course, the exact elements of HCAL for which each group is ultimately responsible can only be defined when the MOUs are signed by the relevant funding agencies. At present, we simply indicate the broad outlines of the proposed responsibilities of the groups.

A single page summary of items rolled up from the version 8 Cost Book [2], together with the responsibility by country for that task, is given in Table 15.3. The cost for the task, at a very high level, is also indicated in the table.

Where available and agreed upon, the responsibilities of individual groups for HCAL items are shown in Table 15.4. As events progress, and as CMS negotiates the MOU with each collaborating institution, these areas of responsibility will change, and are shown here as indicative of the tentative assignment of tasks.

Table 15.3: CMS Cost Book items and the associated responsibility by country for HCAL.

No. Item	Responsible Groups	Total Cost (kCHF) - V8
4. HCAL		44,498
4.1 Barrel - HB		23,895
4.1.1 Barrel		20,067
4.1.1.1 Mechanics	US, (China)	
4.1.1.2 Optics	US	
4.1.1.3 Phototransducers	US	
4.1.1.4 Electronics	US	
4.1.1.5 Tooling	US	
4.1.1.6 Shipping	US	
4.1.1.7 Prototypes	US	
4.1.2 Outer Barrel		3,827
4.1.2.1 Mechanics	India	
4.1.2.2 Optics	India, US	
4.1.2.3 Phototransducers	US	
4.1.2.4 Electronics	US	
4.2 Endcap - HE		13,762
4.2.1 Endcap		12,761
4.2.1.1 Mechanics	RDMS, US	
4.2.1.2 Optics	RDMS, US	
4.2.1.3 Phototransducers	US, RDMS	
4.2.1.4 Electronics	US	
4.2.1.5 Tooling	RDMS	
4.2.1.6 Shipping	RDMS	
4.2.1.7 Prototypes	RDMS	
4.2.2 Outer Endcap		1,001
4.2.2.1 Mechanics	US	
4.2.2.2 Optics	US	
4.2.2.3 Phototransducers	US	
4.2.2.4 Electronics	US	
4.3 Forward - HF		6,841
4.3.1 EM section		1,974
4.3.1.1 Detectors	Hungary, RDMS, Turkey	
4.3.1.2 Electronics	US	
4.3.2 HAD section		3,415
4.3.2.1 Detectors	Hungary, RDMS, Turkey	
4.3.2.2 Electronics	US	
4.3.3 TC section		1,119
4.3.3.1 Detectors	Hungary, RDMS, Turkey	
4.3.3.2 Electronics	US	
4.3.4 Common Systems	Hungary,RDMS,Turkey,US	334

Table 15.4: CMS Cost Book categories and the associated responsibility by institution.

No.	Item	Cost (kCHF)	Responsible Group(s)
4.1.1	**Barrel**	**20,067**	
4.1.1.1	Mechanical Structure	8,469	
4.1.1.1.1	Barrel Design		FNAL, Maryland, Miss
4.1.1.1.2	Barrel Wedges		FNAL
4.1.1.1.3	Bolted Assembly		FNAL, Maryland
4.1.1.2	Optical System	2,162	
4.1.1.2.1	Tile Trays (20 degree)		FNAL, Rochester, FSU
4.1.1.2.2	Optical Cables		UIC, Notre Dame
4.1.1.2.3	Pig Tails		UIC, Rochester, Notre Dame
4.1.1.2.4	Installation		FNAL, Maryland, Rochester
4.1.1.3	Phototransducers	2,694	
4.1.1.3.1	Photodetectors and Bases		Minn, FNAL, Virginia Tech
4.1.1.3.2	Cables and HV Power Supplies		Virginia Tech
4.1.1.3.3	Stabilization System		Notre Dame, Iowa, Iowa State, Purdue
4.1.1.3.4	Temperature Control		FNAL, Notre Dame
4.1.1.3.5	Decoder Boxes		FNAL, Notre Dame
4.1.1.4	Electronics	1,040	
4.1.1.4.1	Electronics EDIA		FNAL
4.1.1.4.2	Electronics mfg. labor		FNAL
4.1.1.4.3	Fermi Channels		CERN, FNAL
4.1.1.4.4	Crates, cooling, low voltage, drivers		FNAL, Miss
4.1.1.4.5	Preamps		FNAL
4.1.1.5	Tooling	3,767	
4.1.1.5.1	Scintillator Tooling		FNAL, Rochester
4.1.1.5.2	Fiber Tooling		UIC, Notre Dame
4.1.1.5.3	Phototransducer Testing		Minn, FNAL
4.1.1.5.4	Other Tooling and Testing Apparatus		FNAL
4.1.1.5.5	Absorber Fabrication Tooling		FNAL, Maryland, Miss
4.1.1.5.6	Installation Tooling		Maryland
4.1.1.6	Shipping	504	
4.1.1.7	Prototypes (2 wedges)	1,430	
4.1.1.7.1	Test Beam Stand		FNAL, IHEP
4.1.1.7.2	Wedges (pre-production)		FNAL
4.1.2	**Outer Barrel**	**3,827**	
4.1.2.1	Mechanical Structure	260	
4.1.2.1.1	Hangers onto Solenoid		TIFR, BARC, IOP, Panjab
4.1.2.2	Optical System	2,118	
4.1.2.2.1	Tile Trays (30 degree)		TIFR, BARC, IOP, Panjab
4.1.2.2.2	Optical Cables		UIC, Notre Dame
4.1.2.2.3	Pig Tails		TIFR, BARC, IOP, Panjab
4.1.2.2.4	Installation		TIFR, BARC, IOP, Panjab
4.1.2.3	Phototransducers	959	
4.1.2.3.1	Photodetectors and Bases		Minn, FNAL, Virginia Tech
4.1.2.3.2	Cables and HV Power		Virginia Tech
4.1.2.3.3	Temperature Control		Notre Dame, FNAL
4.1.2.3.4	Decoder Boxes		FNAL, Notre Dame, Iowa, Purdue, Miss
4.1.2.4	Electronics	490	
4.1.2.4.1	Electronics mfg. labor		FNAL
4.1.2.4.1	Fermi Channels		CERN, FNAL
4.1.2.4.2	Crates, Low Voltage, Cooling		FNAL, Miss
4.1.2.4.3	Preamps		FNAL

Table 15.4 (cont.): CMS Cost Book categories and the associated responsibility by institution.

No.	Item	Cost (kCHF)	Responsible Group(s)
4.2.1	**Endcap**	**12,761**	
4.2.1.1	Mechanical Structure	7,163	
4.2.1.1.1	Endcap Design		JINR, NCPHEP (Minsk)
4.2.1.1.2	Endcap Wedges		NCPHEP (Minsk), INRNE (Sofia), JINR
4.2.1.1.3	Bolted Assembly (included above))		JINR, NCPHEP (Minsk)
4.2.1.1.4	Interface to endcap steel		JINR
4.2.1.2	Optical System	1,590	
4.2.1.2.1	Tile Trays (10 degree)		IHEP, FNAL, INR, KIPT, YERPHI
4.2.1.2.2	Optical Cables		UIC, Notre Dame
4.2.1.2.3	Pig Tails		Rochester, Notre Dame, IHEP
4.2.1.2.4	Installation		IHEP
4.2.1.3	Phototransducers	2,333	
4.2.1.3.1	Photodetectors and Bases		Minn, FNAL, Virginia Tech
4.2.1.3.2	Cables and HV Power Supplies		Virginia Tech
4.2.1.3.3	Stabilization System		Notre Dame, Iowa, Purdue, IHEP
4.2.1.3.4	Temperature Control		FNAL
4.2.1.3.5	Decoder Boxes		FNAL, Notre Dame, IHEP
4.2.1.4	Electronics	891	
4.2.1.4.1	Electronics manufacturing labor		FNAL
4.2.1.4.2	Fermi Channels		CERN, FNAL
4.2.1.4.3	Preamps		FNAL
4.2.1.4.4	Crates, Cooling, Low Voltage		FNAL, Miss, Notre Dame
4.2.1.5	Tooling	260	
4.2.1.5.4	Other Tooling and Testing Apparatus		JINR
4.2.1.5.5	Absorber Fabrication Tooling		JINR, NCPHEP (Minsk)
4.2.1.5.6	Installation Tooling		JINR
4.2.1.6	Shipping (included in Mech. Structure)	0	JINR, IHEP, INR, NCPHEP (Minsk)
4.2.1.7	Prototypes (30-degree sector)	524	JINR, IHEP, INR, NCPHEP (Minsk), INRNE (Sofia)
4.2.2	**Outer Endcap**	**1,001**	
4.2.2.1	Mechanical Structure	26	
4.2.2.1.1	Hangers onto MF1		Maryland
4.2.2.2	Optical System	249	
4.2.2.2.1	Tile Trays (30 degree)		FNAL, Rochester, FSU
4.2.2.2.2	Optical Cables		UIC, Notre Dame
4.2.2.2.3	Pig Tails		UIC, Rochester, Notre Dame
4.2.2.2.4	Installation		FNAL, Maryland, Rochester
4.2.2.3	Phototransducers	481	
4.2.2.3.1	Photodetectors and Bases		Minn, FNAL, Virginia Tech
4.2.2.3.2	Cables and HV Power Supplies		Virginia Tech
4.2.2.3.3	Temperature Control		Notre Dame, Iowa, Iowa State, Purdue
4.2.2.3.4	Decoder Boxes		FNAL, Notre Dame, Miss
4.2.2.4	Electronics	245	
4.2.2.4.1	Electronics mfg. labor		FNAL
4.2.2.4.2	Fermi Channels		CERN, FNAL
4.2.2.4.3	Crates, Low Voltage, Cooling		FNAL
4.2.2.4.4	Preamps		FNAL, Miss, Notre Dame

Table 15.4 (cont.): CMS Cost Book categories and the associated responsibility by institution.

No.	Item	Cost (kCHF)	Responsible Group(s)
4.3.1	**Forward Electromagnetic Section**	**1,974**	
4.3.1.1	Detectors and Components	1,360	
4.3.1.1.1	Absorber		ITEP, METU, MSU
4.3.1.1.2	QQ Fibers + 5%		ITEP, METU, MSU
4.3.1.1.3	QP Fibers + 5%		METU, Iowa
4.3.1.1.4	Optical System		KFKI-RMKI
4.3.1.1.5	QC&A		KFKI-RMKI
4.3.1.1.6	Prototype		all HF groups
4.3.1.1.7	Assembly of EM		ITEP, KFKI-RMKI, METU, MSU
4.3.1.1.8	Installation of EM		all HF groups
4.3.1.2	Electronics	615	
4.3.1.2.1	Photodetectors		Fairfield, Iowa
4.3.1.2.2	Front-end Electronics		FNAL, Boston
4.3.1.2.3	Cabling		Boston
4.3.1.2.4	Power Supplies		Boston, Fairfield, Iowa
4.3.1.2.5	Monitoring		Iowa
4.3.1.2.6	Prototype		all HF groups
4.3.2	**Forward Hadronic Section**	**3,415**	
4.3.2.1	Detectors and Components	2,800	
4.3.2.1.1	Absorber		ITEP, METU, MSU
4.3.2.1.2	QQ Fibers + 5%		ITEP, METU, MSU
4.3.2.1.3	QP Fibers + 5%		METU, Iowa
4.3.2.1.4	Optical System		KFKI-RMKI
4.3.2.1.5	QC&A		KFKI-RMKI
4.3.2.1.6	Prototype		all HF groups
4.3.2.1.7	Assembly of HAD		ITEP, KFKI-RMKI, METU, MSU
4.3.2.1.8	Installation of HAD		all HF groups
4.3.2.2	Electronics	615	
4.3.2.2.1	Photodetectors		Fairfield, Iowa
4.3.2.2.2	Front-end Electronics		FNAL, Boston
4.3.2.2.3	Cabling		Boston
4.3.2.2.4	Power Supplies		Boston, Fairfield, Iowa
4.3.2.2.5	Monitoring		Iowa
4.3.2.2.6	Prototype		all HF groups
4.3.3	**Forward Tailcatcher**	**1,119**	
4.3.3.1	Detectors and Components	947	
4.3.3.1.1	Absorber		ITEP, METU, MSU
4.3.3.1.3	Plastic Fibers + 2%		METU
4.3.3.1.4	Optical System		KFKI-RMKI
4.3.3.1.5	QC&A		KFKI-RMKI
4.3.3.1.7	Assembly of TC		ITEP, KFKI-RMKI, METU, MSU
4.3.3.1.8	Installation of TC		all HF groups
4.3.3.2	Electronics	171	
4.3.3.2.1	Photodetectors		Fairfield, Iowa
4.3.3.2.2	Front-end Electronics		FNAL, Boston
4.3.3.2.3	Cabling		Boston
4.3.3.2.4	Power Supplies		Boston, Fairfield, Iowa
4.3.3.2.5	Monitoring		Iowa
4.3.3.2.6	Prototype		all HF groups

Table 15.4 (cont.): CMS Cost Book categories and the associated responsibility by institution.

No.	Item	Cost (kCHF)	Responsible Group(s)
4.3.4	**Forward Common Systems**	**334**	
4.3.4.1	Mechanical Structure and Support	65	
4.3.4.1.1	Engineering		ITEP, MSU
4.3.4.1.2	Tooling for table		ITEP, MSU
4.3.4.1.3	Jigs		ITEP, MSU
4.3.4.1.4	Test beam supp. str		ITEP, MSU
4.3.4.1.5	Optic. readout jigs		ITEP, MSU
4.3.4.1.6	Alignment		ITEP, MSU
4.3.4.1.7	Horizontal table		ITEP, MSU
4.3.4.1.8	Prototype		ITEP, MSU
4.3.4.2	Assembly/Installation	105	
4.3.4.2.1	Transportable mods.		ITEP, KFKI-RMKI, METU, MSU
4.3.4.2.2	Surface Assembly		all HF groups
4.3.4.2.3	Inst at Exp Beams		all HF groups
4.3.4.2.4	Table design		ITEP, KFKI-RMKI, METU, MSU
4.3.4.2.5	2-axis table		ITEP, KFKI-RMKI, METU, MSU
4.3.4.2.6	2-axis table		ITEP, KFKI-RMKI, METU, MSU
4.3.4.2.7	Table manufac.		ITEP, KFKI-RMKI, METU, MSU
4.3.4.2.8	Cabling (undergrd.)		all HF groups
4.3.4.2.9	Checkout		all HF groups
4.3.4.2.10	Load transf. system		all HF groups
4.3.4.2.11	Inst. manpower		all HF groups
4.3.4.3	Calibration/Monitoring	111	
4.3.4.3.1	System design & integ		Iowa, Purdue
4.3.4.3.2	Housekeeping (temp..)		Iowa
4.3.4.3.3	In situ calib.		Texas Tech, ITEP, MSU
4.3.4.3.4	Test pulses		Boston
4.3.4.3.5	Slow controls (HV...)		Boston
4.3.4.3.6	Slow controls		Boston
4.3.4.3.7	Table remote cont.		ITEP, MSU
4.3.4.3.8	Table remote cont.		ITEP, MSU
4.3.4.3.9	Prototype		all HF groups
4.3.4.3.10	LED, optical comp.		Notre Dame, Iowa, ITEP, MSU
4.3.4.3.11	Manf. Light calib sys.		Iowa
4.3.4.3.12	Inst. manpower		all HF groups
4.3.4.3.13	Installation		all HF groups
4.3.4.3.14	Pulsed N2 lasers		Iowa
4.3.4.3.15	ND Filter wheels		Iowa
4.3.4.3.16	Laser dyes		Iowa
4.3.4.3.17	Optical couplers		Iowa
4.3.4.3.18	Transport fibers		Iowa
4.3.4.4	Service Systems	53	
4.3.4.4.1	Cooling		Boston
4.3.4.4.2	Cooling		Boston
4.3.4.4.3	Crates		Boston

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[1] The Magnet Project Technical Design Report, CERN/LHCC 97-10, May 2, 1997.
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