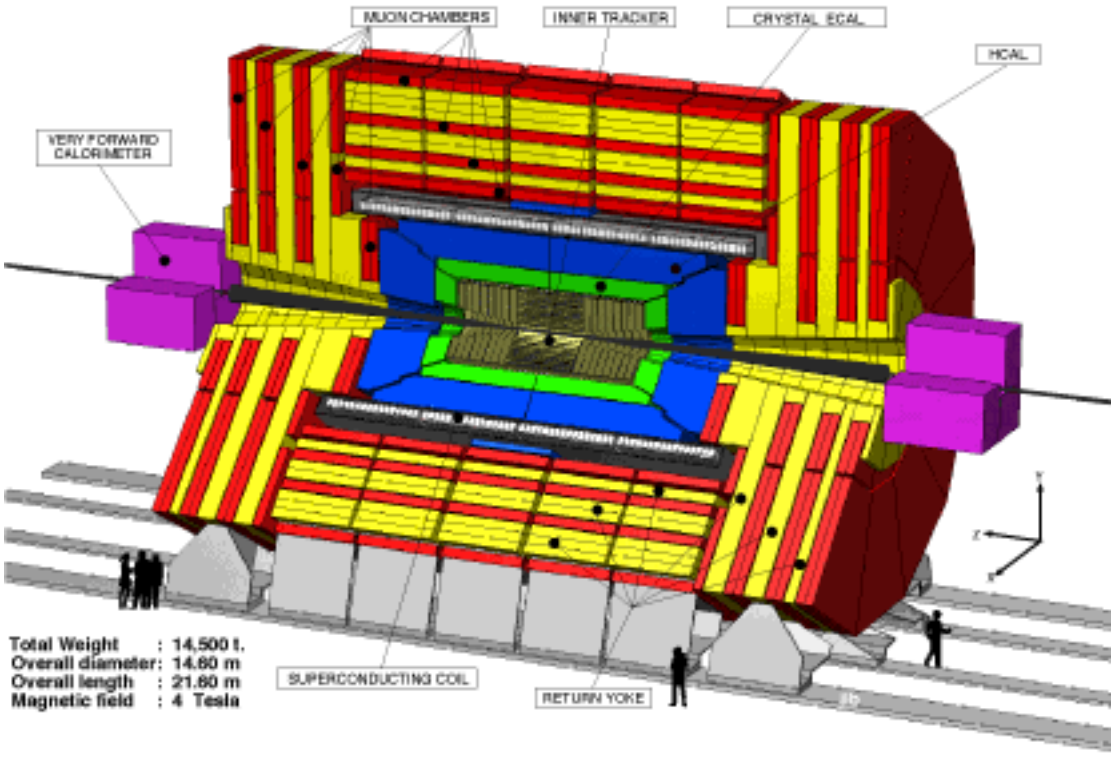
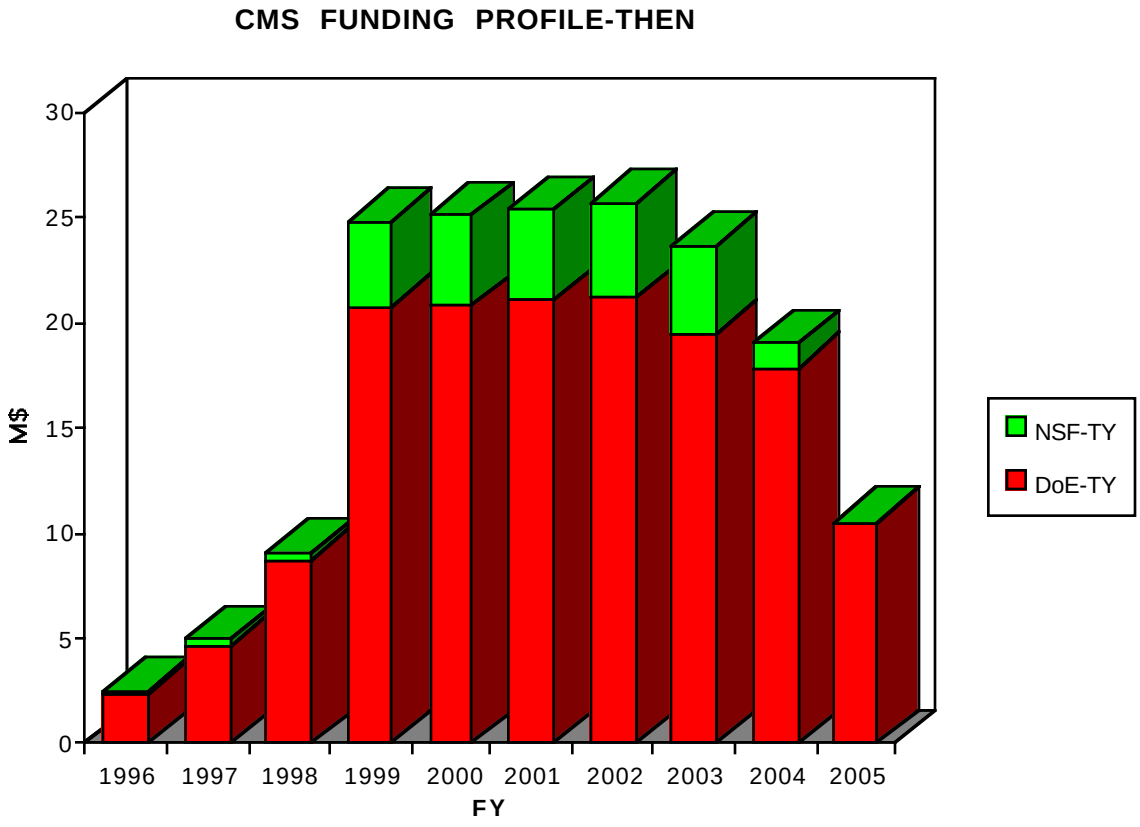
Action Items from the October 30, 1996 DOE/NSF Review

US CMS Collaboration

January 15, 1997



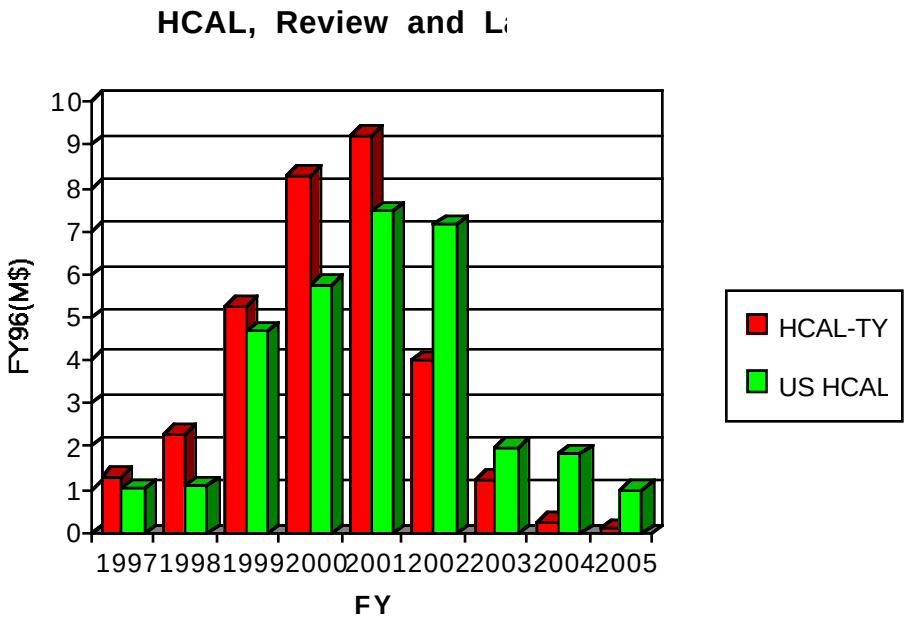
- **Given the following tentative funding profile, develop a plan for a set of deliverables with a consistent cost profile and which is compatible with the CMS schedule.**



We have had a full iteration of the complete CMS general planning. From that first we have abstracted Level 1 milestones that are specific to the deliverables expected from the US CMS collaboration. Attached to the L1 US CMS milestones are L2 milestones appropriate to each subsystem. An example is the HCAL or hadron calorimeter subsystem, where the US groups are responsible for essentially all of the barrel (HB) and the transducers and readout for the endcap (HE) and forward (HF) sectors. The L1 milestones are given here for US CMS as are the CMS HCAL L2 milestones.

To the L2 milestones we plan to attach WBS items using MS Project and the Resource Sheet. WBS numbers are indicated in the HCAL L2 milestone figure. The costs given in the Resource Sheet are then loaded into the L2 schedule. That allows the L2 cost profile to be derived. A first rough cut at the HCAL cost profile has been derived and is compared to what was presented at the October 30 joint DOE/NSF review.

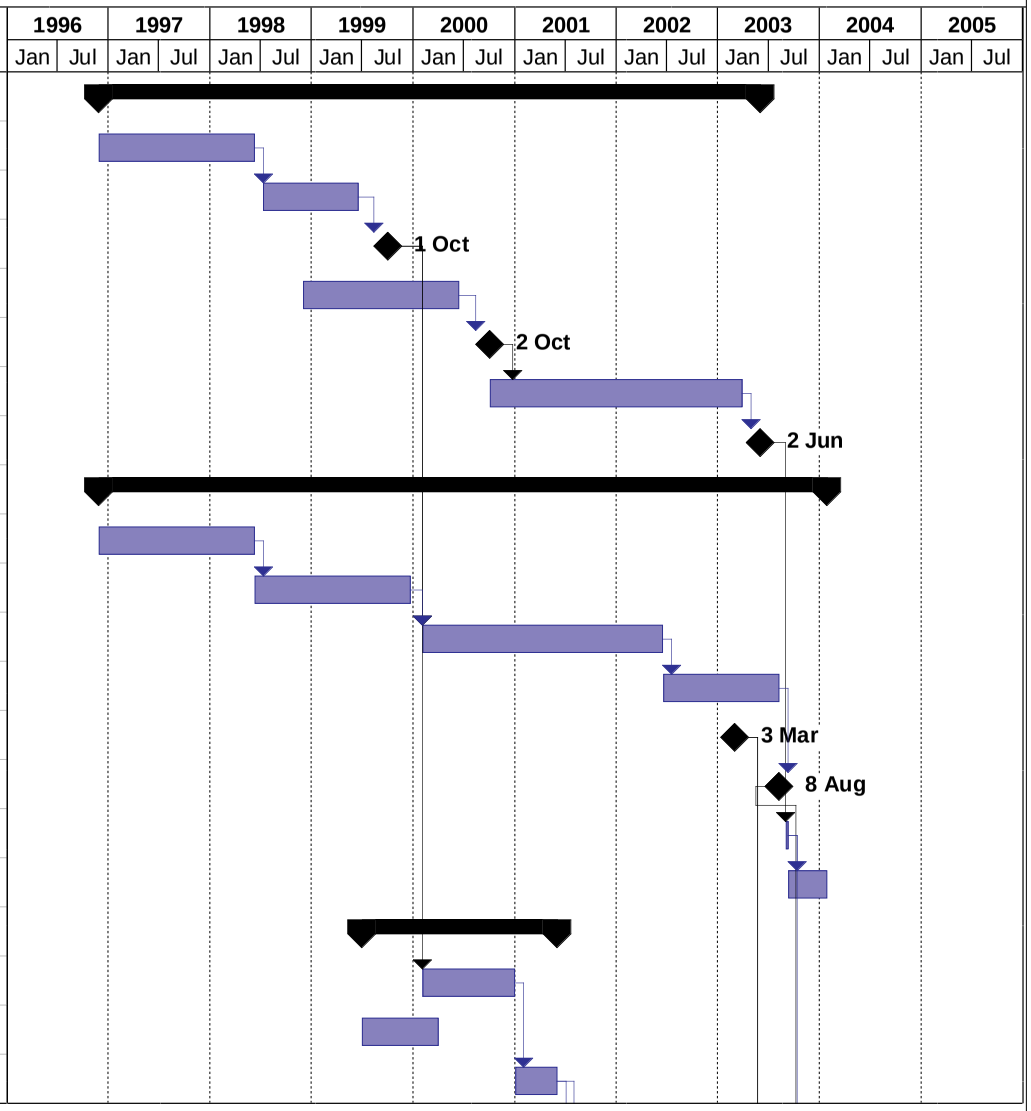
The finer segmentation of HCAL into specific HB, HE and HF costs attached to the US CMS responsibilities leads to differences. In addition, the iteration in planning, in particular a deferral of higher level HCAL trigger and DAQ electronics and of HF to the last possible moment, leads to a more back end loaded cost profile in this latter exercise. We will continue to attempt to match the cost profile to the given funding profile.



The US CMS Management Board is thus in train to produce a resource loaded integrated cost and schedule in time for the June, 1997 "Lehman Review". Our plan and methodology are in place and an example using the HCAL subsystem is shown graphically here. It appears that a cost profile which better matches the funding profile is indeed possible.

US CMS Level 1 Milestones

ID	Task Name	Duration	Start
1	**Experimental Halls**	**1698d**	**27 Nov '96**
2	D=Design,AH=Assembly Hall	400d	27 Nov '96
3	F=Fabricate AH	246d	9 Jul '98
4	BO=Beneficial Occup AH	0d	1 Oct '99
5	D CH=Collision Hall	400d	1 Dec '98
6	LEP stop, Begin F of CH	0d	2 Oct '00
7	F CH	650d	2 Oct '00
8	BO CH	0d	2 Jun '03
9	**Magnet**	**1869d**	**27 Nov '96**
10	R&D magnet	400d	27 Nov '96
11	F magnet	400d	10 Jun '98
12	Assemble coil, tank in AH	617d	3 Feb '00
13	Cool magnet and close	300d	17 Jun '02
14	HB in Vac Tank-test	0d	3 Mar '03
15	Mag power test in AH	0d	8 Aug '03
16	I=Install magnet in CH	6d	1 Sep '03
17	C=Commission magnet in CH	100d	9 Sep '03
18	**Yoke-Barrel(B), Endcap(E)**	**502d**	**1 Jul '99**
19	Assemble YB yoke	237d	3 Feb '00
20	Assemble YE- yoke	197d	1 Jul '99
21	Assemble YE+ yoke	110d	1 Jan '01

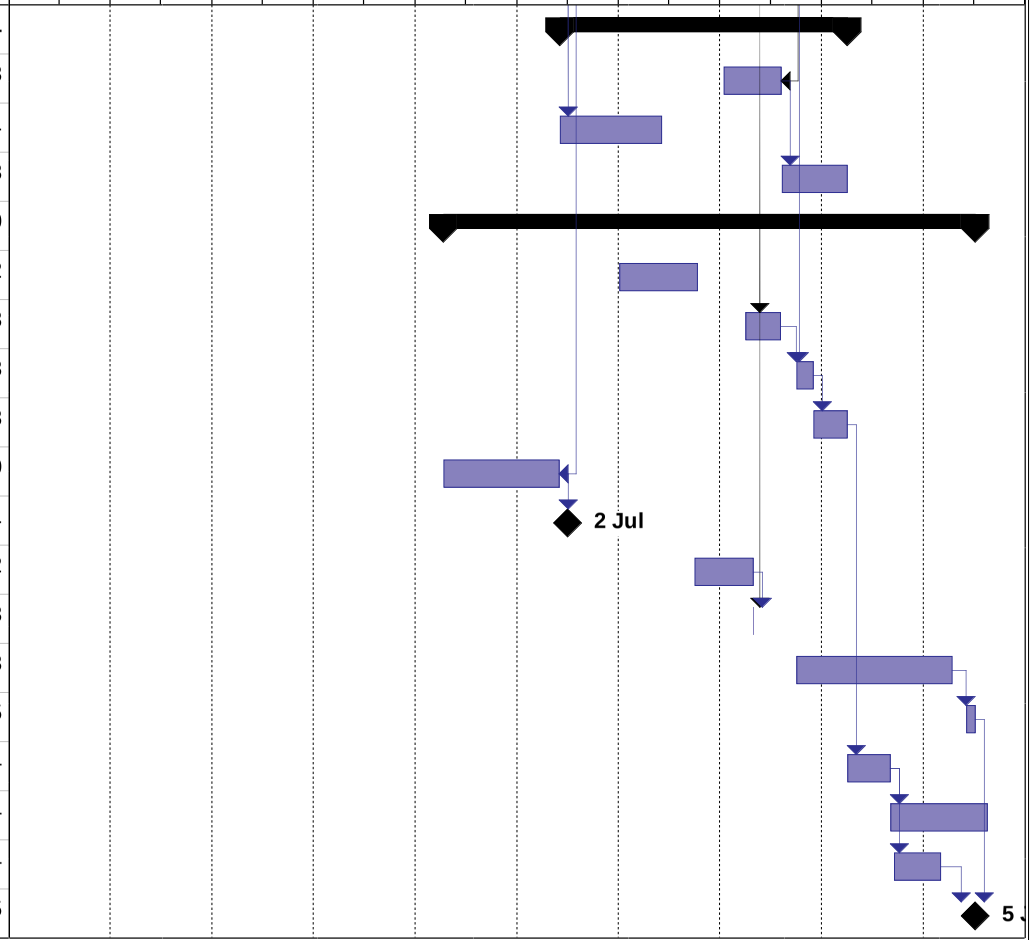


Project: US CMS L1 Milestones
Date: 16 Dec '96

Task
Progress
Milestone
Summary
Rolled Up Task
Rolled Up Milestone
Rolled Up Progress

US CMS Level 1 Milestones

ID	Task Name	Duration	Start
22	**Muon**	**738d**	**4 Jun '01**
23	Assemble CSC YE- in AH	150d	13 Jan '03
24	Assemble CSC YE+ in AH	261d	4 Jun '01
25	I ME in CH	168d	11 Aug '03
26	**HCAL**	**1367d**	**10 Apr '00**
27	Assemble HB+ in AH	200d	4 Jan '02
28	Assemble HB- in AH	90d	1 Apr '03
29	Insert HB into Magnet in CH	44d	1 Oct '03
30	Commission HB	87d	2 Dec '03
31	Assemble HE+	300d	10 Apr '00
32	HE+YE+ connect	0d	2 Jul '01
33	Assemble HE-	150d	1 Oct '02
34	HE-YE- connect	1d	29 Apr '03
35	Assemble HF in AH	400d	1 Oct '03
36	Install HF and shielding	23d	3 Jun '05
37	ECAL - install EB	111d	1 Apr '04
38	ECAL - install EE	250d	3 Sep '04
39	Tracker - install	120d	17 Sep '04
40	First CMS Data	0d	5 Jul '05

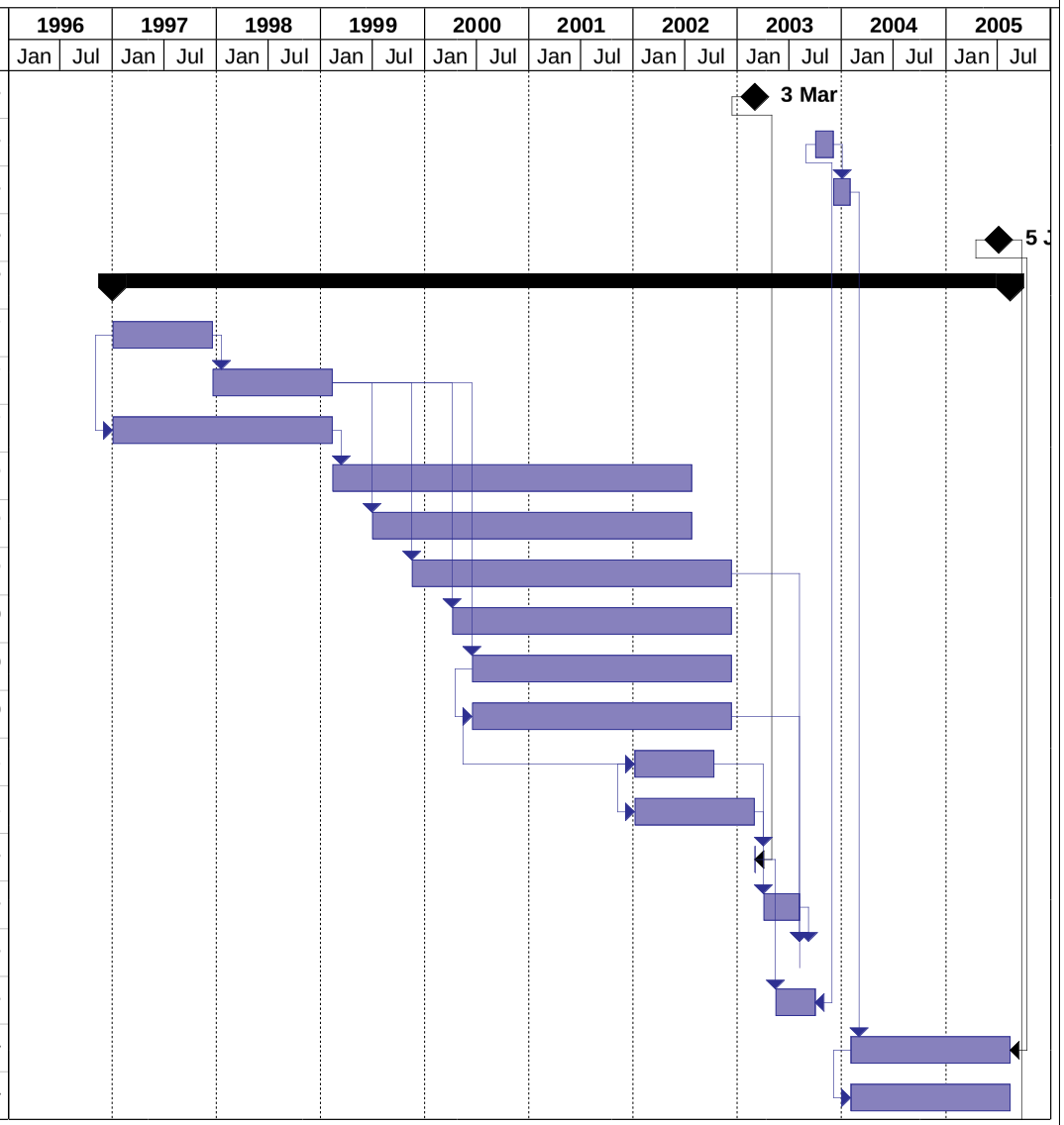


Project: US CMS L1 Milestones
Date: 16 Dec '96

Task
Progress
Milestone
Summary
Rolled Up Task
Rolled Up Milestone
Rolled Up Progress

CMS HCAL L2 Milestones

ID	Task Name	Duration	Start
1	L1 HB- HB+ vac Tank Mate	0d	3 Mar '03
2	L1 HB-Insert HB in Mag CH	45d	30 Sep '03
3	L1 HB-Cable up HB in CH	44d	2 Dec '03
4	L1 HB- First Beam in CMS	0d	5 Jul '05
5	**L2 HB-US CMS**	**2248d**	**1 Jan '97**
6	PPP1 2.1.1.7	250d	1 Jan '97
7	PPP2 (Test Beam-Table)-(.7)	300d	17 Dec '97
8	Wedge Tooling 2.1.1.5	550d	1 Jan '97
9	Absorber F 2.1.1.1	900d	10 Feb '99
10	Optics F 2.1.1.2	800d	30 Jun '99
11	Shipping Abs/Optics 2.1.1.6	800d	17 Nov '99
12	Transducers 2.1.1.3	700d	5 Apr '00
13	Wedge Electronics 2.1.1.4	650d	14 Jun '00
14	Wedge Tests-ship to AH(.1)	650d	14 Jun '00
15	HB+ Assembly/Test in AH(.1)	200d	4 Jan '02
16	Barrel Tooling 2.1.1.5	300d	4 Jan '02
17	HB+ Assembly Complete	1d	28 Feb '03
18	HB- Assembly/Test in AH(.1)	90d	1 Apr '03
19	HB- Assembly Complete	1d	5 Aug '03
20	HB Comission/Test in AH(.1)	100d	13 May '03
21	HB Commission in CH 2.1.1.1	400d	2 Feb '04
22	Trig/DAQ Electronics 2.1.1.4	400d	2 Feb '04

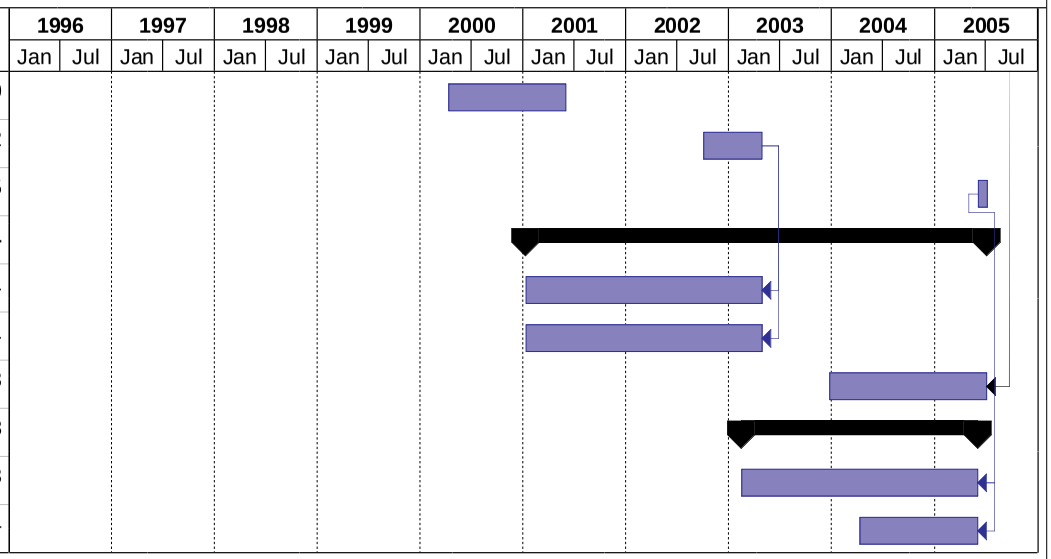


Project: L2 Milestones - HCAL
Date: 16 Dec '96

Task
Progress
Milestone
Summary
Rolled Up Task
Rolled Up Milestone
Rolled Up Progress

CMS HCAL L2 Milestones

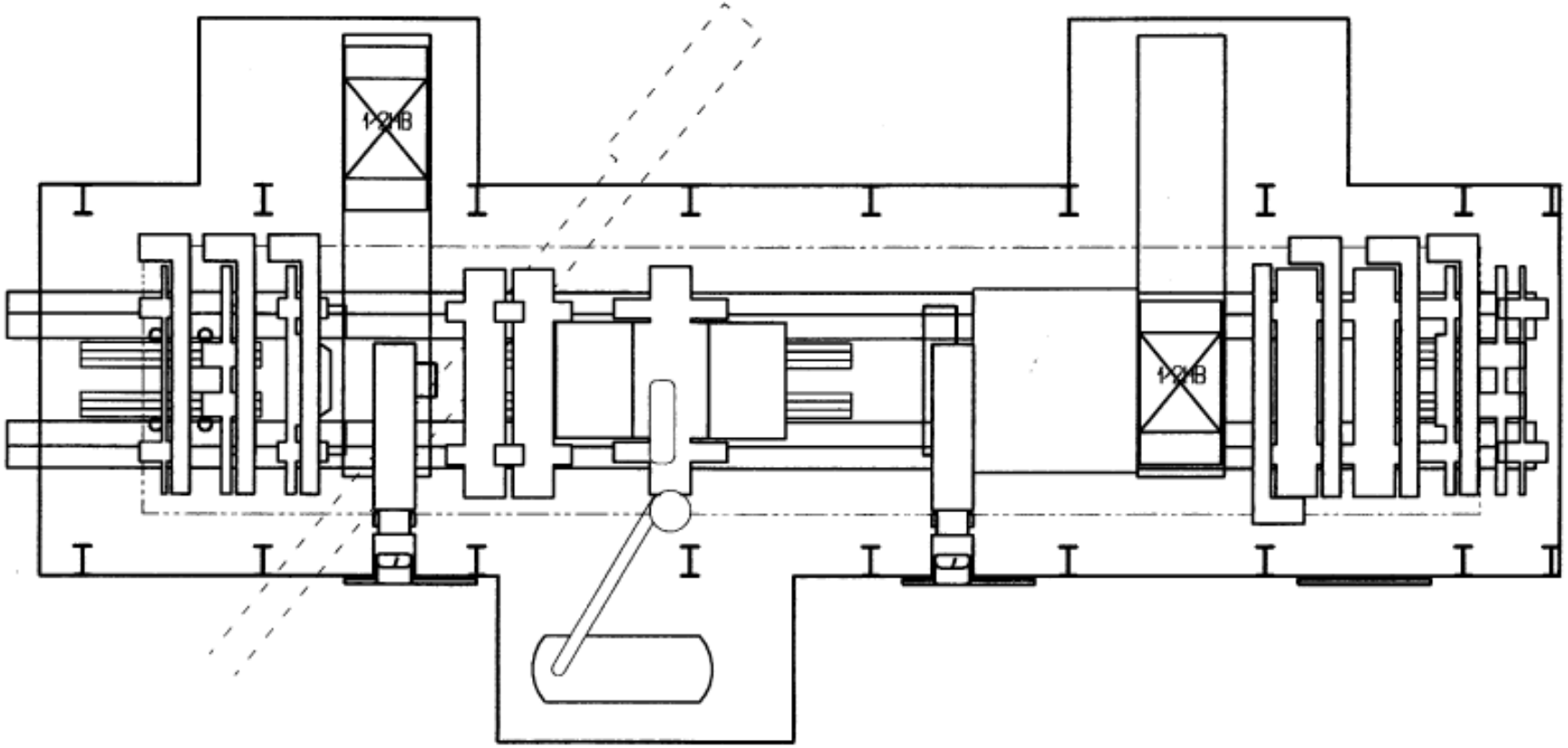
ID	Task Name	Duration	Start
23	L1 Assemble HE+	300d	10 Apr '00
24	L1 Assemble HE-	150d	1 Oct '02
25	L1 HF in CH	23d	3 Jun '05
26	**L2 HE US CMS**	**1170d**	**9 Jan '01**
27	HE Transducer 2.2.1.3	600d	9 Jan '01
28	HE Front Ends 2.2.1.4	600d	9 Jan '01
29	HE Trig/DAQ Elect 2.2.1.4	400d	23 Dec '03
30	**L2 HF US CMS**	**600d**	**14 Feb '03**
31	Assemble HF+, HF- in AH	600d	14 Feb '03
32	Electronics HF	300d	9 Apr '04



Project: L2 Milestones - HCAL
Date: 16 Dec '96

Task
Progress
Milestone
Summary
Rolled Up Task
Rolled Up Milestone
Rolled Up Progress

DISMANTLE WINDING MACHINE
ASSEMBLY 1/2HB-
PLACE YB 0 FOR CONNECTING CRYO LINES
ASSEMBLY MUON CHAMBERS ON YB-1,-2 & YE-1



VEILLET L. 03/12/96

Phase 27 :Du 09/01/03 au 26/02/03

PH27

- **Develop a back-up plan, rescoping deliverables, costs and schedule if contingency became 35% or if the schedule was stretched out by one year.**

We first note that recent contingencies are rather lower. BABAR was begun at 23% of the base cost, and the Fermilab Main Injector was begun at the 20% level. The MI contingency was defined at the end of the conceptual design phase. To date the MI contingency utilization has been at a level of 10% of costs. We take this as an "existence proof" that a project at the conceptual design phase, if properly managed, can be brought in on time and on (under) budget.

For US CMS the TEC less Common Projects and Project Management is 116.3 M$. Of that sum, 69% is taken up by the HCAL and EMU subsystems. The HCAL contingency as a fraction of base cost is 31%. We note that there are 3 vendor estimates for the Cu absorber and that a pre-production Prototype (PPP) will be assembled at FNAL before the Lehman review. The active elements are directly comparable to the already built CDF end plug upgrade, (a factory exists that US CMS will inherit) while the electronics are a modified version (bipolar prototypes available in the summer of 1997) of the existing SDC designed KTEV electronics. Thus we argue that 35% is simply inappropriate for a contingency assignment for HCAL.

For the EMU system a prototype CSC has been built and tested in the CERN test beam, and a full sized PPP has been built and is being tested with cosmic rays. A factory for CSC production has been laid out and the cost drivers have been attacked. Winding is done without transfer frames. A Panasonic soldering robot has been purchased and tested. Panels have been procured, and the routing machine for the panel strips has been procured and tested. We believe that the CSC production costs are rather well estimated. We note that in chambers the largest cost uncertainty in the past has often been in labor. The US CMS collaboration has taken steps to reduce its labor contingency by having other members of the collaboration take a large fraction of the responsibility for the labor component of the CSCs. The electronics

have gone through several, increasingly complex, rounds of ASIC development. We therefore believe that 35% is simply inappropriate as a contingency level for the EMU system.

As HCAL and EMU are 69% of the costs of subsystems, we think that a 35% overall rate is not reasonable. Indeed, we have applied a 40% contingency for the forward pixels, which is reasonable for a system still in the R&D phase.

Therefore, we believe that the US CMS WBS has a properly assigned contingency level given the advanced basis for the cost estimates. In point of fact, the contingency level can only be truly assessed at the appropriate WBS level, say sixth, in a comprehensive review. Our intent is to address the contingency at the June Lehman review at a convincing level of scrutiny. In preparation, we are again doing a bottoms up contingency analysis using a modified SDC methodology. In particular, the ECAL and EMU subsystems are re-examining their contingency analyses.

On the issue of schedule risk we note that US CMS is responsible for complete projects. Hence, the US CMS collaboration would simply complete their responsibilities even if the CMS schedule should slip by a year. As noted previously, the issue is rather the potential mismatch in a funding profile that comes later than the projected cost profile. If the question is a stretch out in the funding profile, then obviously escalation would increase the costs by ~ 3% of the uncompleted items in the project. It is not at all clear how to advance the construction over the funding in this case, as the collaboration has the ability to get "loans" from its member institutions only at the few M$ level, while the problem is likely to be rather worse than that given the expected ~ 25 M$/year cost profile.

- **Develop a plan for incremental operating costs during and after the period of detector construction including computing, operating costs, and incremental needs.**

To set the scale, we first note that the present ~ 233 Ph.D. physicists on US CMS represent, on the basis of statistics from the NRC, ~ 15% of all HEP experimentalists in the United States.

We have surveyed existing support for US physicists at ZEUS and the LEP experiments. We find ~ 5 k$/physicist for common operating expenses (category A), ~ 5 k$/physicist for maintenance of US supplied equipment (category B), and ~ 10k$/physicist for incremental travel, and support of students and postdocs. If we apply these existing standards of support we arrive at ~ 4M$/year for incremental operations costs of US CMS. Note that this does not, of course, include physicist or technical staff basic salary, only the increment due to operating at CERN.

In addition, we have participated in the Technical Proposal for CMS Computing and have submitted our own US CMS Software and Computing Plan, as Appendix A of the Project Status Report of October 15, 1996. The estimated costs implied in Appendix A prior to 2003 are ~ 6 M$ which support simulations, networks and software professionals.

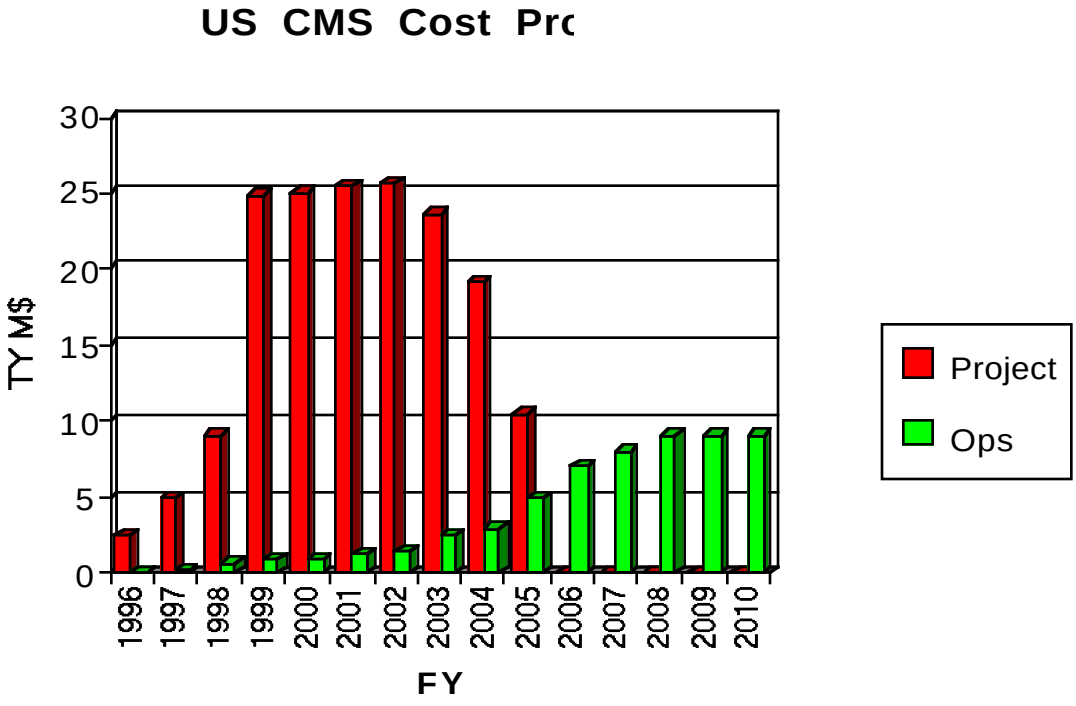
Based again on LEP experience, we then expect a sharp ramp-up of operating expenses for 2-3 years prior to first beam. Note that this corresponds to the time when the detector elements are first installed in the underground Collision Hall, which makes sense from a scheduling viewpoint. We estimate that the computing costs will reach a level of 5M$/year, scaling from LEP experience and again applying existing standards of support by DOE.

We note that we are requesting nothing in excess of existing levels of support. In fact, it can be argued that US CMS is a particularly good deal. The collaboration will not need to pay for operation of the LHC. Therefore, assuming that US HEP is supported at a level of 650 M$, scaling to 15% of all US HEP experimentalists would argue that US CMS should receive 97 M$/year. Our incremental

costs are, in fact, <10% of this level; surely a great bargain for the US. Note also that this level is consistent with general DOE levels of support for user groups operating at most accelerator laboratories.

In fact, the collaboration is acutely aware of the need to reduce operating costs by trying hard to insure that all collaborators will be able to access and analyze data at their home institution. That goal is explicitly spelled out in the document "Technical Proposal for CMS Computing", CERN/LHCC 96-45. To that end we have explored and will continue to explore remote control rooms, network augmentation and regional computing centers located in the US.

Our plan for US CMS Computing has already been presented on October 30, 1996. That plan is fully compatible with the CMS plan. Our estimate of operations costs, category A + category B + computing, is fully compatible with existing LEP and ZEUS levels of support. Indeed, it is a bargain for US HEP as US CMS comprises ~ 15% of the entire "base program' in the US.



The US CMS Collaboration is acutely aware that requests for incremental operations support from the "base program" must be

made in a responsible and coherent fashion. Therefore, all requests for "supplementary support" will be vetted by US CMS in exactly the same way as supplementary travel support, earmarked for US CMS, has been in the past. The US CMS Spokesperson will transmit such requests with the advice and consent of the US CMS Management Board after full discussion and consultation within the collaboration. Thus, US CMS will take full responsibility for cost control of operations and pre-operations costs earmarked for US CMS in addition to formal "project costs" as defined in the US CMS Project Management Plan.