

US interest in Tracker Upgrades

- Fairly broad interest (most institutions)
 - Several production sites could contribute to Phase I
 - FPix production
 - Contribution to BPix production
 - Many groups already started on R&D for Phase II
 - Interests include: Track Trigger, CO₂ Cooling, Fast Data Links, Sensors and FE electronics etc. etc.
 - Large effort on simulation
 - Interest in physics benchmarking

US CMS Phase 1 Upgrade interests*

Detector	Comment
Pixel Detector	Replacement of the current system with 3 barrel layers (with the option of adding a 4th) and 3 forward disks; more radiation hard sensors; new readout chip to improve dead time; reduction of the material budget. Task shared with PSI and others.
HCAL	Implementation of longitudinal segmentation and precision timing to cope with the higher luminosities. Silicon Photomultipliers (SiPM) provide the high gain needed for segmentation and timing.
EMU	Addition of chambers in the 4th Endcap Muon layer (ME _{4/2}) to add redundancy to reduce accidental rate and to preserve a low a P _T threshold for the L1 MuonTrigger; upgrade the layer 1 (ME _{1/1}) electronics to include it in the trigger for added coverage.
TRIGGER	Rebuilding of the Trigger using new technologies, such as μ TCA technology (cell phone towers). This will permit flexible clustering and implementation of isolation algorithms. Both upgraded Calorimeter and CSC triggers would produce information for eventual combination with L1 tracking trigger information.
ECAL	New Trigger/readout receiver electronics to provide enhanced detailed information to the upgraded Regional Calorimeter Trigger

**Subject to negotiation with CMS*



Snapshot of current US R&D

System	Group	Area
HCAL/EMU/Pixel	FNAL	SiPm/ME ₄₂ / Pixel cooling/Optolinks
HCAL	Iowa	FE/mechanics
HCAL	Princeton	SiPm/Decoding
HCAL	Maryland	Backend/trigger
HCAL	Boston	SiPM/
HCAL/ECAL	Minnesota	Backend/trigger/Opto-links
ECAL	Virginia	Backend/trigger/new photodetectors
ECAL	Caltech	Rad-hard Crystals
EMU	Wisconsin	ME ₄₂ Chambers
EMU	TAMU	Software/trigger
EMU	Rice	Trigger
EMU	Florida	Trigger
EMU	OSU	ME ₁₁ FE
TRIGGER	Wisconsin	HCAL/ECAL
TRACKER	UCSB	Mechanics
TRACKER	Rochester	Sensor/Beam test
TRACKER	Brown	Sensor/Beam Test
TRACKER	Cornell	Sensors/trigger
TRACKER	Purdue	Sensors/mechanics/Layout
TRACKER	PIRE	Sensors/ ROC/ Interconnections
SOFTWARE	UCR, Vanderbilt,..	Tracker Straw-man/trigger

US CMS upgrade R&D

- Upgrade budget* is increasing

System	FY08	FY09
HCAL	285,000	488,000
ECAL	50,000	49,000
EMU	15,000	260,000
STRIP	183,000	234,816
PIXEL	670,000	842,072
TRIGGER	0	269,268
DAQ	0	40,000
SIMULATION	100,000	90,000
DATA LINKS		226,844
TRAVEL	50,000	
TOTAL	1,353,000	2,500,000

- Tracker and HCAL R&D dominate for Phase 1.

**Includes M&S, engineering and technical labor (but not physicists)*

Phase 1 cost

- Presented to DOE and NSF in September 2008
 - *NB: still to be negotiated with the funding agencies*

Sub-Detector	Estimated Cost in FYo8 \$	Estimated US Share in FYo8 \$
Pixel System	30.2M	7.0-9.0M
CSC Muon System	8.6M	6.0-7.0M
RPC Muon System(*)	16.1M	0.0M
DT mini crates (*)	1.7M	0.0M
HCAL	10.2M	5.0-7.0M
ECAL	2.2M	1.0M
Trigger	8.5M	3.5-5.0M
DAQ	3.4M	0.0M
Tracker TDR for Phase 2	6.0M	0.0M
Infrastructure	10.0M	0.0M
Project Management	2.0M	1.0M
TOTAL	98.9M	23.5-30.0M

Costs would also cover technical and engineering labor as well as M&S

FY09 Budget

System	FY09 Requests	FY09 allocated	%
HCAL	758,500	488,000	19.5
ECAL	267,000	49,000	2.0
EMU	270,000	260,000	10.4
STRIP	513,374	234,816	9.4
PIXEL	1,561,808	842,072	33.7
TRIGGER	288,268	269,268	10.8
DAQ	180,000	40,000	1.6
SIMU	465,062	90,000	3.6
DATA LINKS	428,540	226,844	9.1
TOTAL	4,732,552	2,500,000	

- Focus on phase 1 needs and critical phase 2 issues (sensors)
 - Phase 1: 83 %
 - HCAL SiPM : 15%
 - Pixel mechanics/cooling/ power: 30%
 - Phase 2: 17%
- Restricted R&D on Opto-links
- Substantially more activity/interest this year resulting in funding limitations.



R&D budget goals*

- Seek to increase R&D budget to a steady 4.5M\$/y
 - Phase 1 dominates up to FY10

System	FYo8	FYo9	FY10	FY11
Phase 1	1,123,000	2,075,000	3,000,000	1,500,000
Phase 2	230,000	425,000	1,000,000	3,000,000
TOTAL	1,353,000	2,500,000	4,000,000	4,500,000

**Assumes funding follows current guidance and no emergencies arise that can't be handled with management reserve funds*