DRAFT REV 2

GLAST Large Area Telescope:

AntiCoincidence Detector (ACD) Overview WBS 4.1.6

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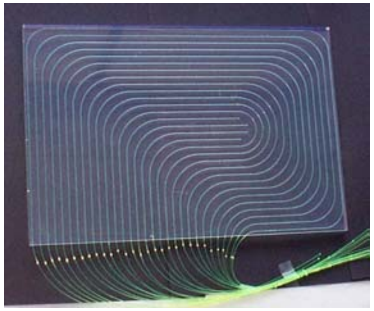
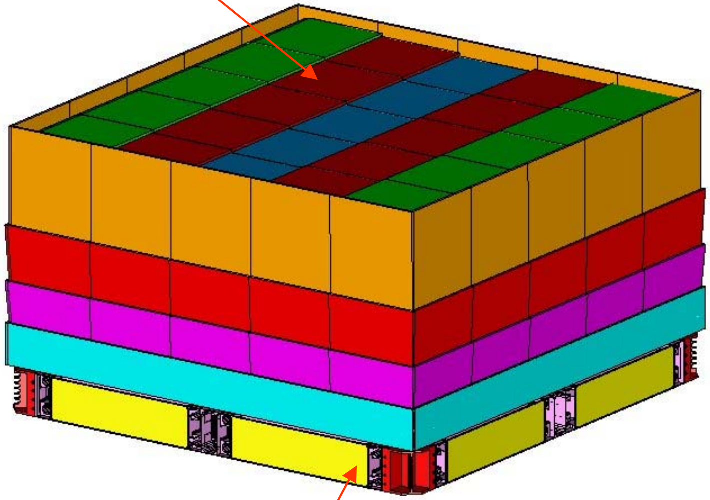
Outline - ACD

- Overview
- Level III Requirements Summary
- Technical Heritage
- Organization
- Flight Experience
- Status of January Recommendations
- Summary Schedule
- Summary Cost Plan

Anticoincidence Detector Overview





- TILE SHELL ASSEMBLY
  - 89 Plastic scintillator tiles
  - Waveshifting fiber light collection (with clear fiber light guides for long runs)
  - Two sets of fibers for each tile
  - Tiles overlap in one dimension
  - 8 scintillating fiber ribbons cover gaps in other dimension (not shown)
  - Supported on self-standing composite shell
  - Covered by thermal blanket + micrometeoroid shield (not shown)
- BASE ELECTRONICS ASSEMBLY
  - 194 photomultiplier tube sensors (2/tile)
  - 12 electronics boards (two sets of 6), each handling up to 18 phototubes. High voltage power supply on each board.

Level III Key Requirements Summary

Reference: LAT-SS-00016

Parameter	Requirement	Expected Performance	Verification Method
Detection of Charged Particles	**≥ 0.9997 average detection efficiency over entire area of ACD (less for bottom row of tiles)**	**≥0.9997** **≥0.99 (bottom tiles)**	**Test and Analysis**
Fast VETO signal	Logic signal 50-700 nsec after passage of charged particle	50-700 nsec	Test
PHA signal	For each phototube, pulse height measurement for each Trigger Acknowledge (TACK) Below 10 MIP, precision of <0.02 MIP or 5% (whichever larger) Above 10 MIP, precision of < 1 MIP or 2% (whichever larger)	< 0.02 MIP or 5% < 1 MIP or 2%	Test and Analysis
False VETO rate - backsplash	**< 20% false VETO's due to calorimeter backsplash at 300 GeV**	**< 20%**	**Analysis**
False VETO rate - noise	< 1% gamma-ray rejection from false VETO's due to electrical noise	< 1%	Analysis
High Threshold (Heavy Nuclei) Detection	Detection of highly-ionized particles (C-N-O or heavier) for calorimeter calibration.	Yes	Test and Analysis
Size	Outside: 1796 x1796 x 1015 mm Inside Grid: 1574 x 1574 x 204.7 mm Inside TKR: 1515.5 x 1515.5 x 650 mm	1796 x1796 x 1015 1574 x 1574 x 204.7 1515.5 x 1515.5 x 650	Test
Mass	≤ 235 kg (228 + 7 allocated)	228	Test
Power	< 31 Watts (conditioned)	14	Test
Instrument Lifetime	Minimum 5 yrs	> 5 yr.	Analysis

ACD Technical Heritage

- **Plastic Scintillator** - used in all previous gamma-ray telescopes OSO-3, SAS-2, COS-B, CGRO (all 4 instruments), plus many cosmic ray experiments.
- **Waveshifting fibers** - used in GLAST LAT Balloon Flight Engineering Model (BFEM). Waveshifting bars used by HEXTE on RXTE (same material in a different geometry)
- **Photomultiplier tubes** - used in all previous gamma-ray telescopes. HEXTE/RXTE used a commercial version of the same tube we are using (Hamamatsu 4443), and GOLF on SOHO used the same tube as the ACD except for the cathode material (Hamamatsu 4444)
- **High Voltage Bias Supplies** - used in all previous gamma-ray telescopes, plus many cosmic ray experiments.
- **Electronics** - similar ASIC's (same designer) used on the BFEM. Discriminators, PHA and logic signals similar to many flight instruments.
- **Micrometeoroid Shield** - Improved version (more layers, stronger materials) of shield that protected EGRET successfully for nine years.

ACD Organization Chart

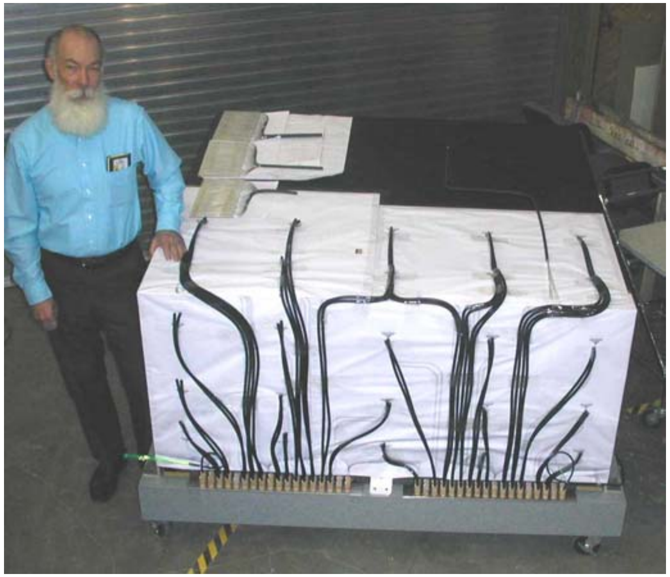
- **ACD Subsystem** 4.1.6 — Dave Thompson, Subsystem Manager
  - **ACD management** 4.1.6.1 — Tom Johnson, Manager; Deanna Adamczyk - Financial Resources; Mike Walsh - Scheduling
    - **ACD Design and Science Support** 4.1.6.1.3 — Alexander Moiseev, Lead
    - **ACD Systems Engineering** 4.1.6.1.2 — George Shiblie, Mike Amato
    - **ACD Reliability and Quality Assurance** 4.1.6.2 — Patricia Huber, Lead
    - **Tile Shell Assembly** 4.1.6.3 — Ken Segal, Lead
      - **Tile Detector Assemblies** 4.1.6.3.2 — A. Moiseev, Lead
    - **Base Electronics Assembly** 4.1.6.4 — Glenn Unger, Lead
    - **Micrometeoroid Shield / Thermal Blanket** 4.1.6.5 — Ken Segal, Lead; Carlton Peters, Thermal Lead
    - **Hardware Integration & Test** 4.1.6.7 — Jim La, Lead
    - **LAT Instrument Integration & Test Support** 4.1.6.8 — Jim La, Lead
    - **Mission Integration & Test Support** 4.1.6.9 — Bob Hartman, Lead
    - **Ground Support Facilities & Equipment** 4.1.6.B — Jim La, Ken Segal, Glenn Unger

ACD Team Space Flight Experience

- Science
  - Dave Thompson - SAS-2, EGRET
  - Bob Hartman - SAS-2, EGRET
  - Alex Moiseev - GAMMA-1
- Engineering
  - Tom Johnson - BBXRT, COBE, EUVE, SAMPEX, TRMM, HST
  - George Shiblie - FUSE, MAP
  - Mike Amato - Spartan 201, STIS (HST), Stereo COR1
  - Ken Segal - TRMM, HST, POES, EOS
  - Glenn Unger - MOLA, XTE, MAP
  - Dave Sheppard - BBXRT, XTE, TGRS, POEMS, GRS, Swift
  - Satpal Singh - EPACT and TGRS on WIND, Swift
  - Art Ruitberg - EGRET, COBE, POLAR, WIND, CASSINI, Triana
  - Bob Baker - HEAO, SMM, EGRET, BBXRT, XRS, XTE, Swift
  - Jim La - TDRS, POES, VCL/MBLA, Spartan, ROMPS, SLA, SEM
  - Carlton Peters - VCL, CATSAT, MAP, Triana

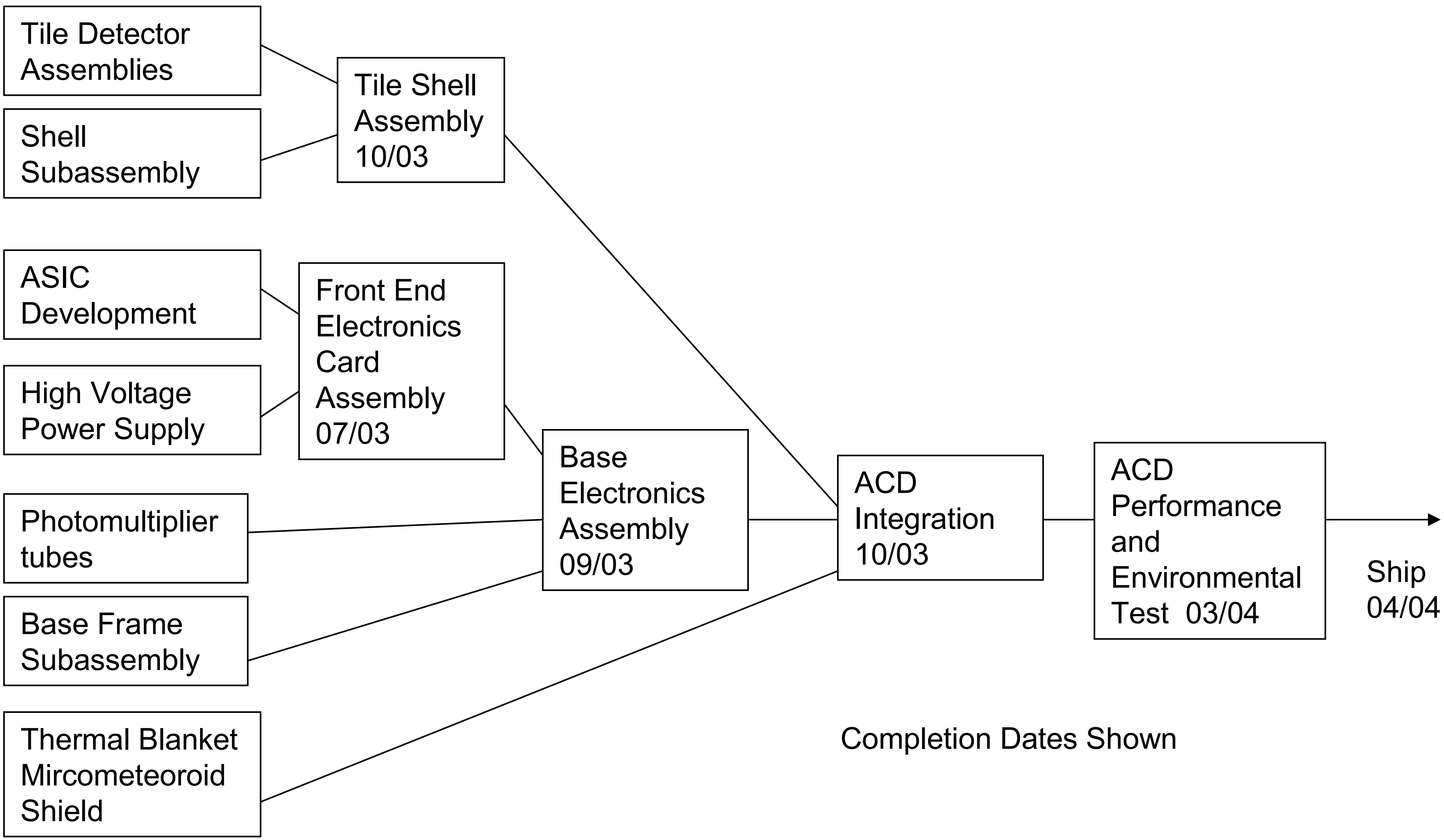
Status of January Review Recommendations

- Finalize tile and fiber layout, build mock-up
  - In progress using completed mock-up
- Test light yield of full optical system
  - Delivery of prototype flight-like tile assembly occurred last week
- Demonstrate electronic noise is low
  - Use first engineering board - Sept.
- Thermal cycle tile assemblies
  - In progress (no problems after 140 cycles)
- Plan for calibration of ACD system
  - Basic approach verified, draft completed
- Improve ASIC schedule margin
  - New approved screening process helps
- Complete streamlined WBS in Primavera
  - Done
- Analyze critical path and contingency
  - Done

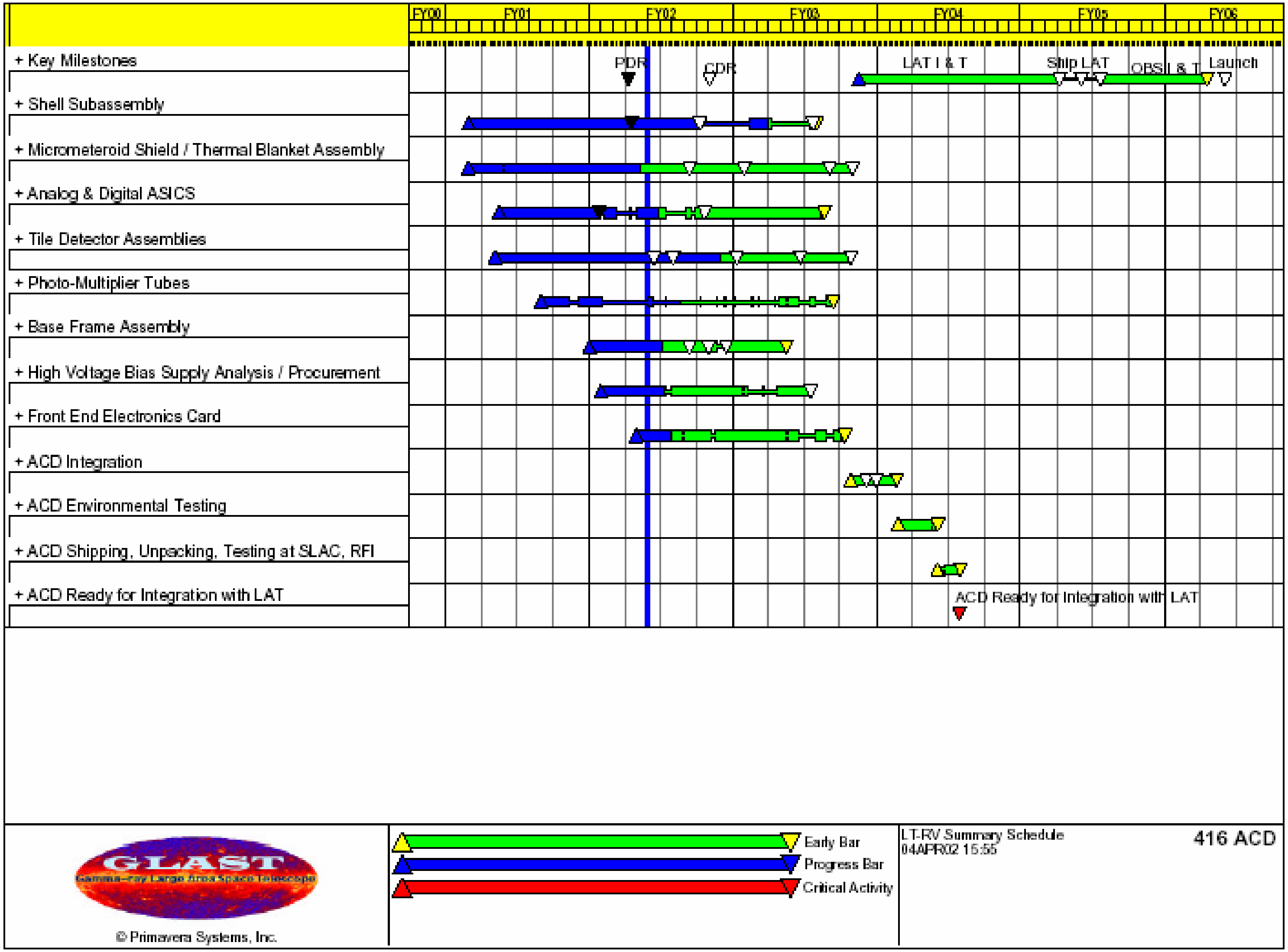


Full-scale mock-up of ACD being used for tile placement and fiber routing

ACD Work Flow Overview



Top-Level Schedule



ACD Critical Path - Digital ASIC

Activity	Dates
Fabricate first digital ASIC	4/8/02 - 7/2/02
Test first digital ASIC	7/3/02 - 7/22/02
Design second digital ASIC	7/23/02 - 8/12/02
Fabricate second digital ASIC	8/13/02 - 11/6/02
Test second digital ASIC	11/7/02 - 11/29/02
Design flight digital ASIC	12/2/02 - 12/13/02
Fabricate flight digital ASIC	12/16/02 - 4/4/03
Slice die for flight digital ASIC	4/7/03 - 4/22/03
Package flight digital ASIC	4/23/03 - 5/8/03
QA inspect flight digital ASIC	5/9/03 - 5/9/03
Testing services for flight digital ASIC	5/12/03 - 5/20/03
Populate FREE boards with flight digital ASIC	5/21/03 - 5/28/03
Complete and test FREE boards	6/13/03 - 7/10/03
Prepare FREE boards for integration	7/30/03 - 8/5/03
Install FREE boards	8/8/03 - 9/5/03
Install and test TDA	8/13/03 - 10/1/03
Complete ACD integration	10/2/03 - 10/17/03
ACD functional/performance test	10/20/03 - 11/21/03
ACD environmental tests	11/24/03 - 3/03/04
Shipping preparation	3/04/04 - 3/5/04
Shipping to SLAC	3/6/04 - 4/6/04

Cost/Manpower Overview by Fiscal Year

FY	Cost ($M) + Commit	FTE	Activities
2000	0.44	3.4	Planning, test
2001	0.88	7.4	Planning, test, design
2002	3.41	24.3	Complete design, start fabrication
2003	3.00	20.2	Fabrication, assembly, test
2004	1.62	14.1	Integration, test, delivery, LAT support
2005	0.53	4.3	LAT, GLAST support
2006	0.15	1.0	GLAST support
TOTAL	10.03	74.7	

Cost/Manpower Overview by Task

WBS Element	Total Cost	M&S	Labor	Travel	Taxes	Contract FTE	CS FTE
4.1.6.1 Management/Systems Eng/Science Support	4,739,719	125,504	1,603,934	57,001	2,953,280	14.58	21.53
4.1.6.2 Safety & Mission Assurance	542,273	0	542,273	0		5.91	0
4.1.6.3 Tile Shell Assembly	1,620,208	1,022,467	578,739	19,001		3.85	2.44
4.1.6.4 Base Electronics Assembly	1,778,575	894,926	877,168	6,481		5.96	3.99
4.1.6.5 Micrometeoroid Shield/Thermal Blanket	150,041	121,003	29,039	0		0.29	0.31
4.1.6.6 Mechanical Qual & Calibration Unit	202,138	102,001	94,129	6,008		0.91	0.44
4.1.6.7 Integration & Test	472,084	182,005	265,079	25,000		2.65	7.22
4.1.6.8 LAT Integration & Test Support	35,001	0	0	35,001		0	0
4.1.6.9 Mission Integration & Test	39,473	33,253	6,220	0		0.05	0.13
4.1.6.B GSE	450,569	228,301	222,268	0		2.31	2.01
Total	10,030,082	2,709,460	4,218,849	148,493	2,953,280	36.51	38.23

Civil Service personnel salaries are paid by Goddard, not the LAT.

Taxes: Goddard overhead, charged on the basis of on-site FTE and total cost.

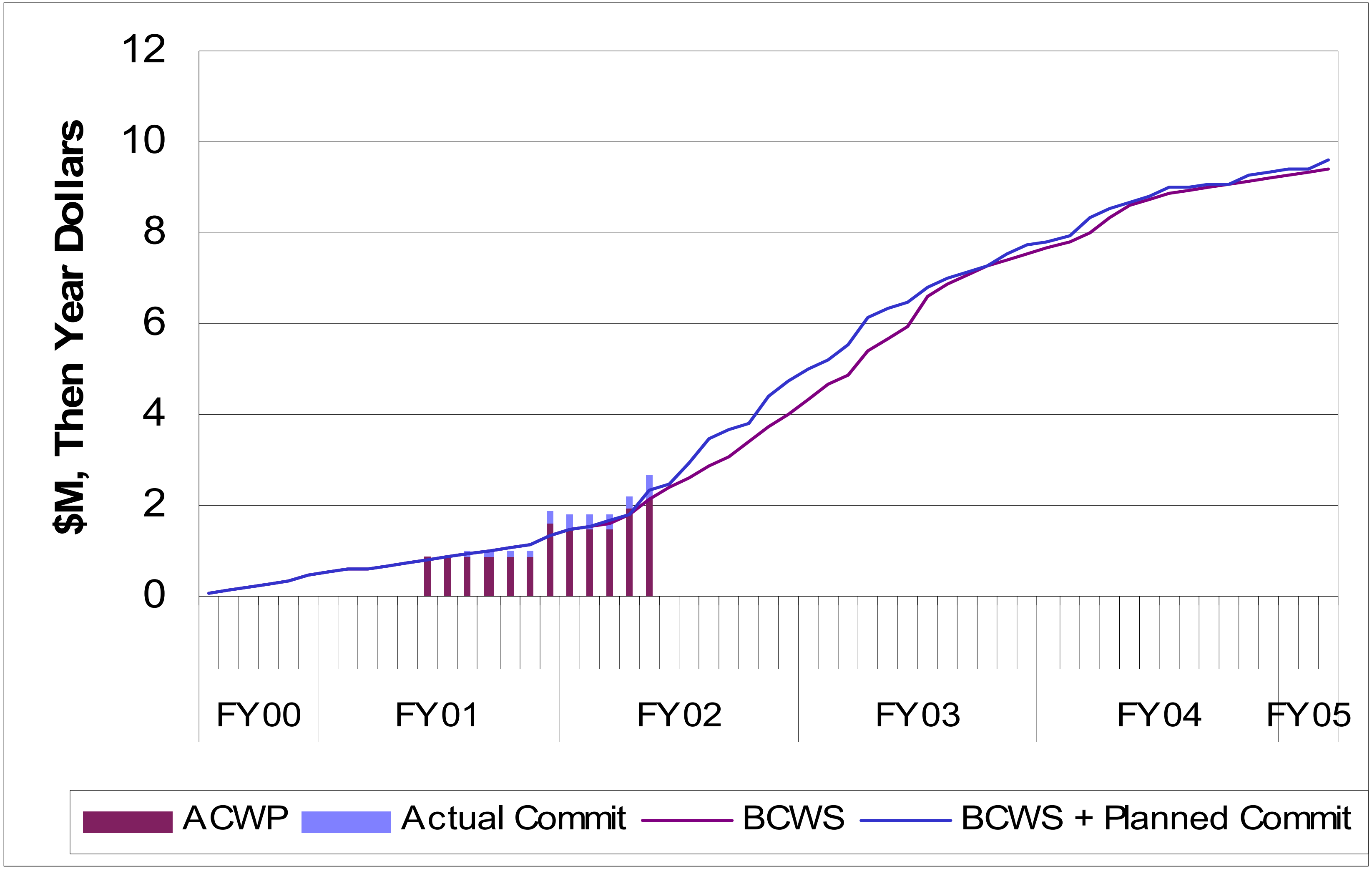
Manpower Skill Mix by Fiscal Year

RESOURCE	2002	2003	2004	2005	2006
GSFC CS Clerical	0.05	0.05	0.02	0	0
GSFC CS Engineer	7.88	5.56	4.34	0.6	0.04
GSFC CS Prof Admin	1.06	1.17	0.97	0.71	0.12
GSFC CS R&D Supervisory	0.7	0.8	0.81	0.4	0
GSFC CS Scientist	1.01	1.01	1.01	1.01	0.49
GSFC CS Technician	1.21	1.51	0.5	0	0
GSFC Contractor I&T Engineer	0.08	0.14	0	0	0
GSFC Quality Assurance	1.88	2.1	1.26	0	0
GSFC Contractor On-Site Admin	0.67	0.65	0.58	0.27	0
GSFC Contractor On-Site Clerical	0.5	0.5	0.3	0.04	0
GSFC Contractor Sr Engineer	5.46	1.74	1.48	0.29	0.01
GSFC Contractor Jr Engineer	0.89	1.75	1.11	0	0
GSFC Sr Scientist	1.01	1.01	1.01	1.01	0.37
TOTAL	**24.3**	**20.25**	**14.12**	**4.33**	**1.03**

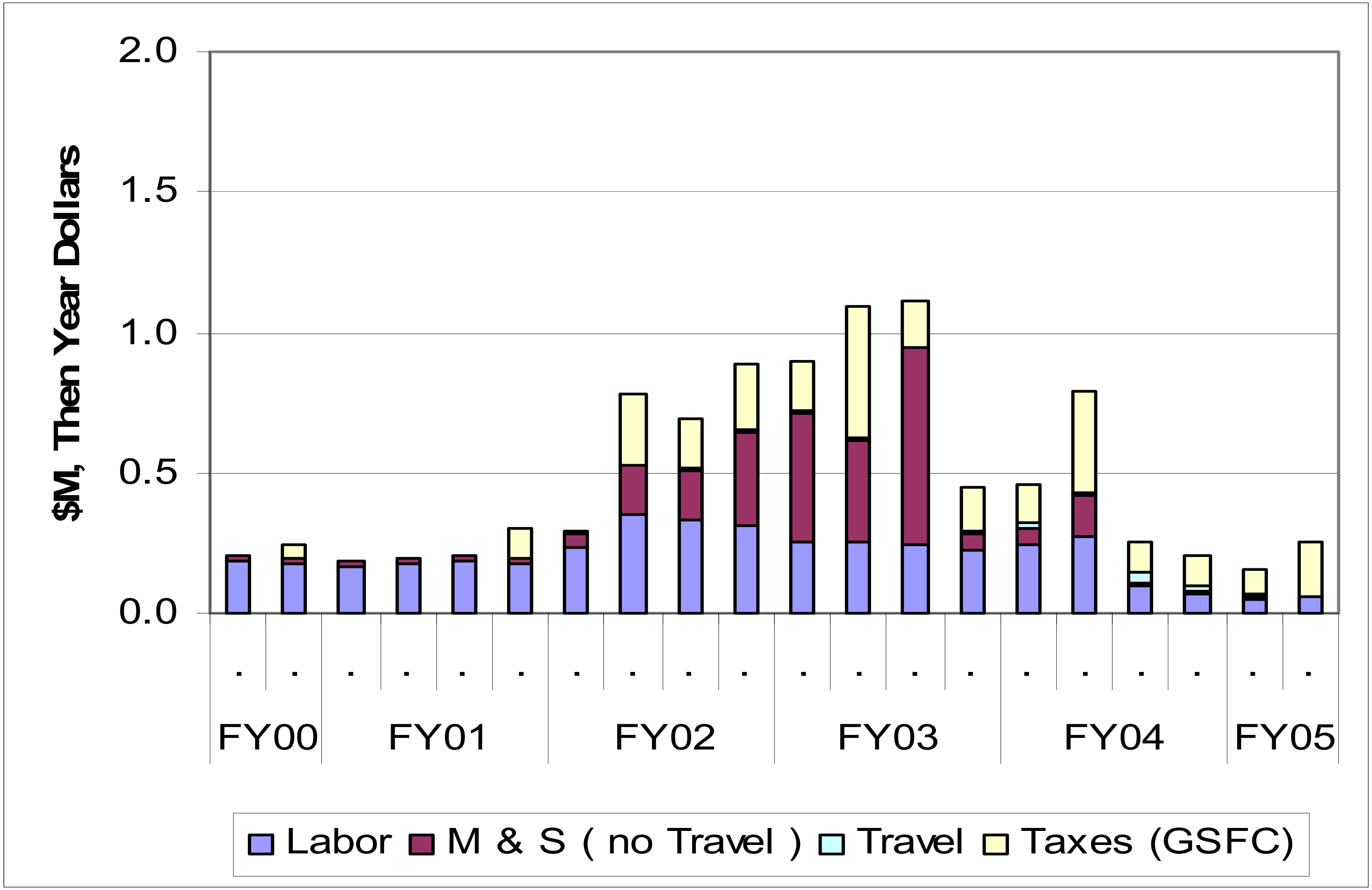
ACD - Largest Procurements

Item	Cost	Supplier	Basis of Estimate	Contingency
Flight shell (composite)	$360,000	Composite vendor	3 vendor estimates	28%
Flight phototubes	330,000	Hamamatsu	Fixed price, competitive	10%
Flight tile detector assemblies	195,000	Fermilab	Cost plus fixed fee contract	32%
Micrometeoroid shield design/test	100,000	JSC	Fixed price	21%
Clear fiber bundles/connectors	97,000	GSFC	Eng. Estimate, prev. exper.	38%
Digital ASIC (2 runs)	88,300	MOSIS	Fixed price	
Thermal Vac Cables	62,166	GSFC	Previous experience	32%
Tile detector tiedown hardware	61,500	Composite vendor	Vendor estimate	32%
Flt. Spare tile detector assmbl.	61,000	Fermilab	Cost plus fixed fee contract	32%
Test shell fab and assembly	42,000	Composite vendor	Eng. Estimate, prev. exper.	24%
HV bias supplies fabrication	40,000	SAIC	Vendor quotation	38%
Test tile detector assemblies	30,000	Fermilab	Cost plus fixed fee contract	32%
COTS phototubes	30,000	Hamamatsu	Fixed price, catalog	10%
Base frame handling dolly fab	30,000	GSFC	Mech. Branch estimate	32%
Tile shell handling dolly fab	25,999	GSFC	Mech. Branch estimate	32%
Shipping container fab	25,999	GSFC	Mech. Branch estimate	32%
Tile detector development	25,000	Fermilab	Cost plus fixed fee contract	32%
Fiber ribbon flight unit fab	22,000	Wash. U.	Vendor quotation	32%
Turnover/assembly dolly fab	21,999	GSFC	Mech. Branch estimate	32%
TOTAL	**$1,647,963**			

ACD Cost & Commitments



ACD Cost Type



Some ACD Risks - Not Likely, But Possible

Risk	Probability of Occurrence	Recovery	Schedule cost (approx)	How we avoid it
Tiles or ribbons + PMT fail efficiency test	0.4	Re-design and re-make	6 weeks	Early testing, detailed simulations
Flaw in flight ASIC	0.2	Fix, re-make, re-test ASIC	12 weeks (minimum)	Careful simulations, complete testing of first version
QA finds problem in parts after assembly	0.1	Replace, re-test	3-8 weeks	Choose reliable parts, test early
Mechanical interference found during assembly	0.1	Re-make parts	3-6 weeks	Design checks
Civil Servant test conductors pulled off for another project	0.4	Hire, train contractors	2 weeks	High visibility with GSFC management
EMI/EMC produces noisy signals	0.3	Improve grounding, shielding, then re-test	4-6 weeks	Careful design, early subassembly tests
Waveshifting fibers break in vibration	0.2	Disassemble, repair, re-assemble, re-test	10 weeks	Subassembly test, careful tiedown
Tile comes loose in acoustics	0.1	Disassemble, repair, re-assemble, re-test	10 weeks	Conservative design, analysis
Corona in Thermal Vac around HV	0.1	Disassemble, re-pot, re-assemble, re-test	10 weeks	Early testing of subassembly
HVBS or PMT fails in test	0.1	Disassemble, diagnose, replace, re-assemble, re-test	10 weeks	Burn-in

ACD Issues/Concerns

- The schedule is tight. The ACD critical path (digital ASIC) has little room for delay. We are drawing on SLAC ASIC experience to minimize risk.
- There is no ACD Engineering Model. Although testing will be done on components and subassemblies, the first full-scale test will be on the flight unit.
- The ACD is not completely redundant. Loss of a tile, a phototube, a high voltage supply, or an electronics channel would reduce the ACD efficiency, although risk assessment shows not enough loss to have a significant impact on science.
- The ACD is dependent on Goddard Civil Service manpower and test facilities. We have a commitment from Goddard management and fairly high visibility, but crises in other programs have been known to pull manpower away and tie up facilities.

Backup material

What Happened in January?

- In late Summer, 2001, the ACD was descoped (fewer tiles, fewer HV supplies, some electronics shifted to LAT) for cost saving.
- At the same time, the ACD team had personnel changes:
  - Subsystem Manager: Ormes → Thompson
  - Instrument Manager: Larson → Johnson
  - Also new mechanical, electrical, I&T, systems engineers
- Rebudgeting and development of the new WBS schedule were complicated by the mismatch between Goddard and PMCS accounting methods.
- By the January review, we had not completely incorporated the new cost/schedule into the PMCS.
- The PDR/Baseline Review team correctly concluded that the ACD did not have an adequate baseline plan.
- We spent January-March streamlining and documenting the cost and schedule within the PMCS. We now have a coherent, practical plan for building the ACD.
- The ACD team is now stable and ready to move on.

Level 3 Key Milestones

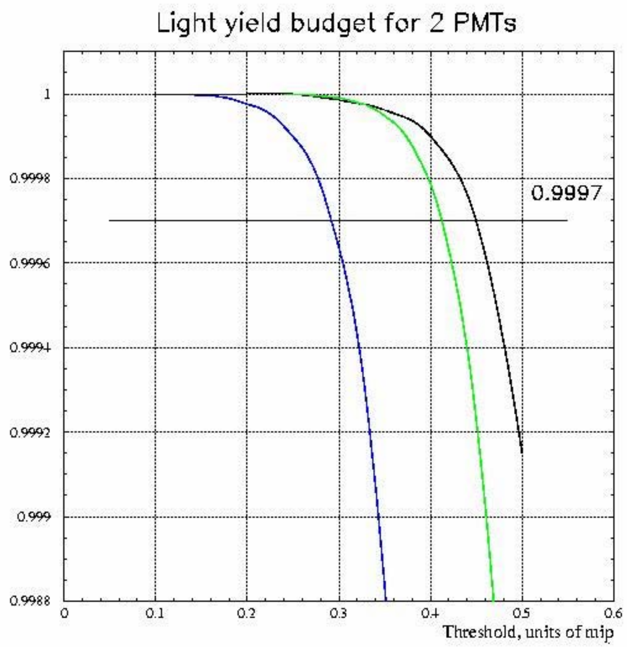
ACD Subsystem Requirements Review	03/20/01
Anticoincidence Detector PDR	07/25/01
Prototype Electronics Module (Elec to ACD)	04/15/02
EGSE Workstation / Software #1 (I&T to ACD)	04/15/02
High Voltage Power Supply (Bd & Prts)-ACD toElec	06/03/02
Anticoincidence Detector CDR	06/26/02
Test/Screening Board for EM1 - ACD to Elec	07/01/02
Doc defining Calibration Model (ACD to I&T)	01/03/03
(11) FREE Bds & ASICS, (1) Fully Tested Bd - EM2	03/03/03
Flight Grid Ready for ACD Fit Test-(Mech to ACD)	05/08/03
ACD Calibration Test Unit at SLAC, Tested & RFI	11/03/03
ACD Test Scripts (from ACD to I&T)	02/02/04
ACD Flight Unit at SLAC, Tested/Inspected & RFI	**04/26/04**

Selected Level IV Milestones

TDA Tiedown Development Fab/Assembly Complete	05/29/02
Micrometeoroid Shield Design complete	06/13/02
TU Shell Delivered to GSFC	07/09/02
TU Base Frame Delivered	07/31/02
TU TDA Acceptance Testing Complete	10/09/02
Flight Base Frame delivered to GSFC	02/12/03
Flight TDA Acceptance Testing complete	04/22/03
Flight HVPS Units tested	04/15/03
Flight Shell delivered to GSFC	04/22/03
Deliver qualified mechanical hardware	07/29/03
Flight micrometeoroid shield available	07/31/03
Flight BEA Integration complete	09/05/03
Flight TSA integration complete	10/01/03
Pre-environmental review	11/21/03
Pre-ship review	03/03/04

Meeting the Level III Key Requirements

Detection Efficiency 0.9997

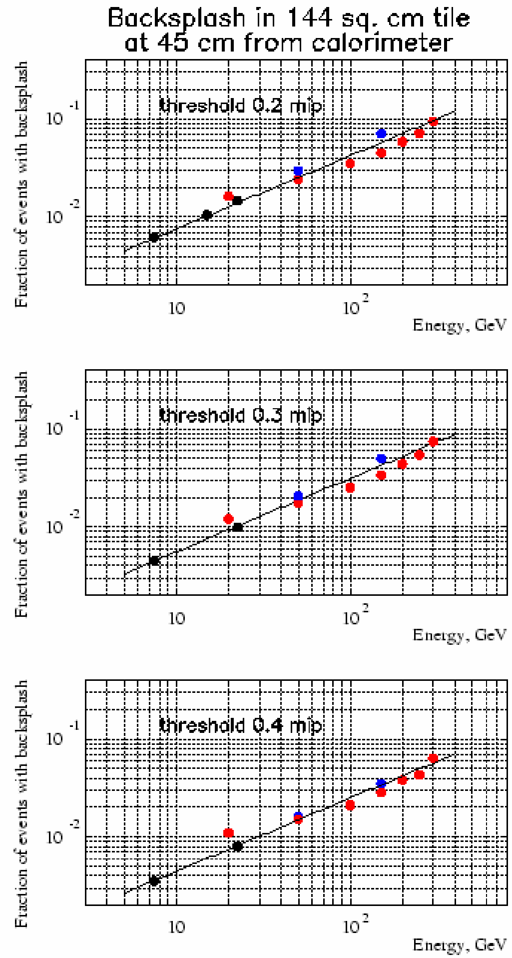


Black line: measured efficiency

Green line: efficiency with 15% loss

Blue line: efficiency with 40% loss

Backsplash Loss <20% at 300 GeV



Measurements at SLAC and CERN