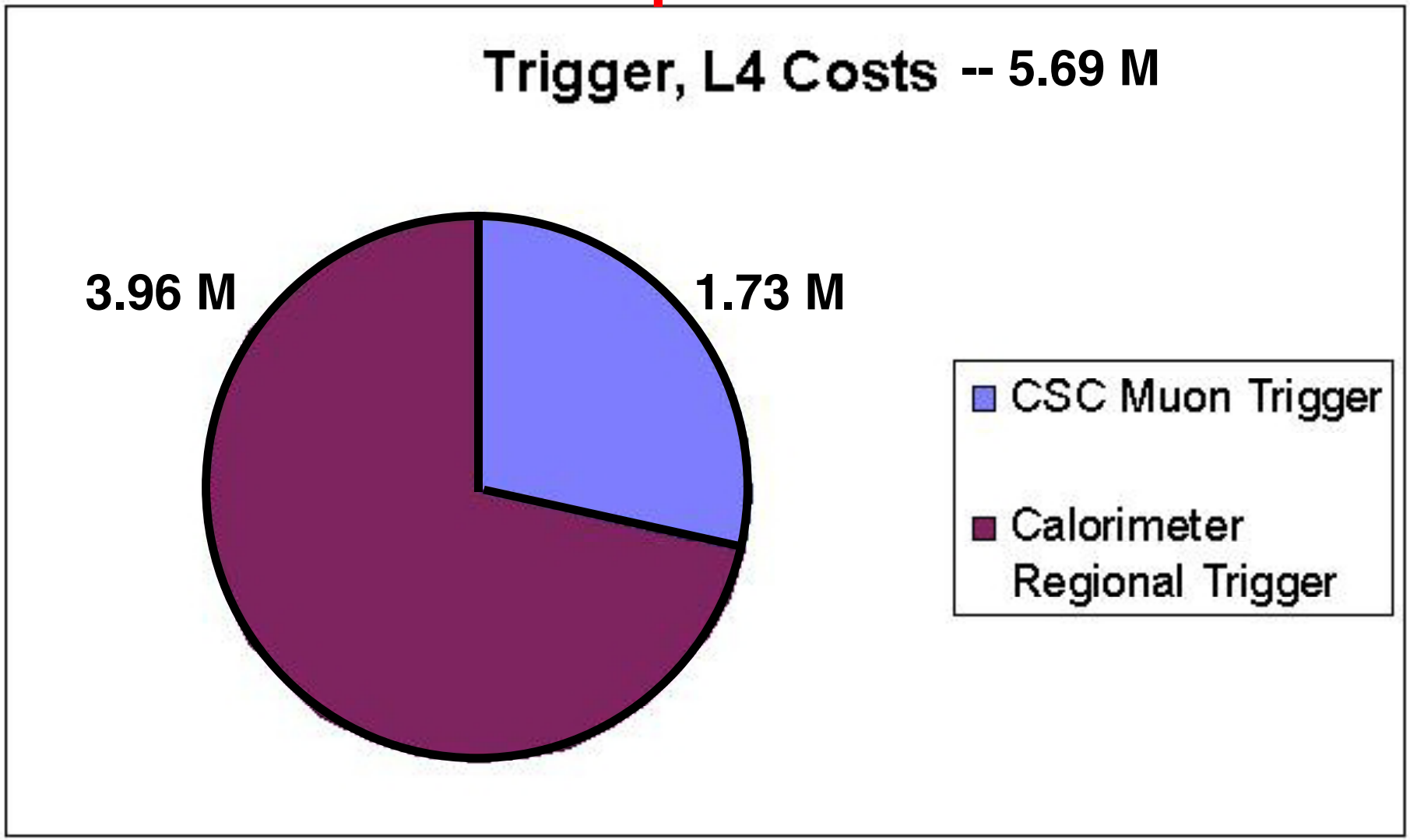
Trigger Cost & Schedule

Wesley Smith, *U. Wisconsin*
CMS Trigger Project Manager

DOE/NSF Review
May 9, 2001

Baseline L4 Trigger Costs

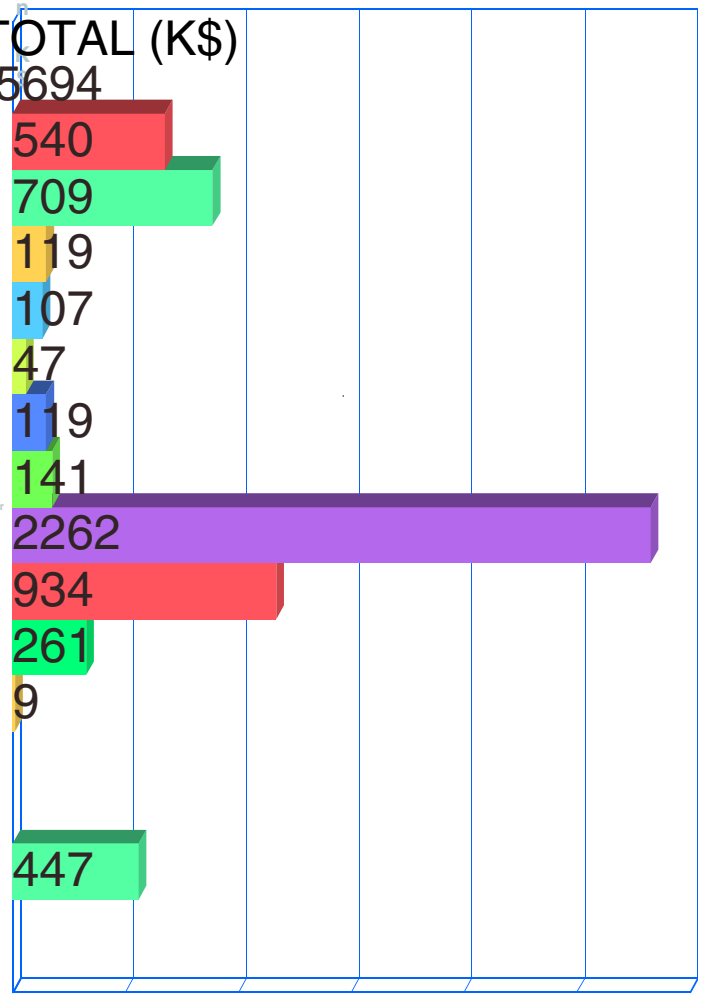
From April '00 Review



Calorimeter Trig. Costs at L5

(April 2000 numbers)

WBS	Item	Base(k$)	Cont(%)	TOTAL (K$)
3.1.2	Cal. Regional Trigger	3,956	44	5694
3.1.2.1	Prototypes	377	43	540
3.1.2.2	Preproduction ASICs	473	50	709
3.1.2.3	Test Facilities	79	50	119
3.1.2.4	Power Supplies	82	30	107
3.1.2.5	Crates	36	30	47
3.1.2.6	Backplane	77	54	119
3.1.2.7	Clock & Control Card	101	40	141
3.1.2.8	Receiver Card	1,545	46	2262
3.1.2.9	Electron ID Card	707	32	934
3.1.2.10	Jet Summary Card	174	50	261
3.1.2.11	Cables	7	30	9
3.1.2.12	DAQ Processor			
3.1.2.13	Crate Monitor Card			
3.1.2.14	Trigger Tests	298	50	447
3.1.2.15	Trigger Project Management			



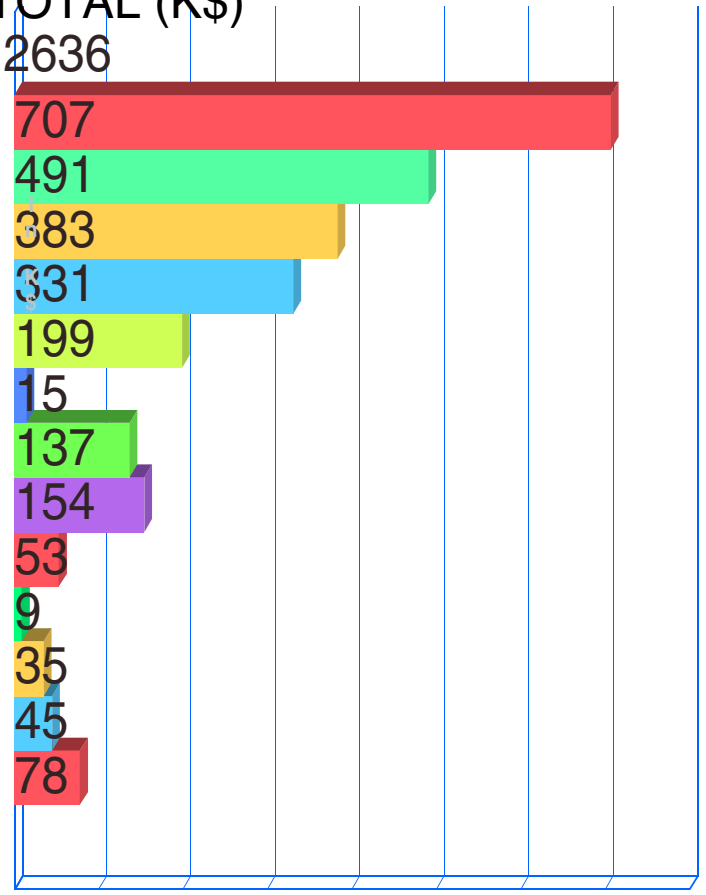
Changes since April 2000 Review:

- Backplane parts costs properly included (+ $88K)
- Additional Prototype Cycle for Serial Link for new Vitesse chip (+ $110K)
- Extra manpower for delayed installation (+ $100K)

Muon Trigger Costs at L5

(April 2000 numbers)

WBS	ITEM	BASE(K$)	Cont(%)	TOTAL (K$)
3.1.1	CSC Muon Trigger	1,733	52	2636
3.1.1.1	Muon Port Cards (MPC)	475	49	707
3.1.1.2	Sector Receivers (SR)	328	50	491
3.1.1.3	Sector Proc. (SP-CSC)	232	65	383
3.1.1.4	Overlap SP (SP-OVR)	202	64	331
3.1.1.5	Clock&Control (CCC)	142	40	199
3.1.1.6	Crate Monitor Cards	10	50	15
3.1.1.7	Muon Backplanes	94	47	137
3.1.1.15	Muon Sorter	104	48	154
3.1.1.8	Crate Controllers	35	50	53
3.1.1.9	Muon Crates	6	50	9
3.1.1.10	Muon Power Supplies	23	50	35
3.1.1.11	Additional Cables	30	50	45
3.1.1.12	Trigger System Tests	52	50	78
3.1.1.13	Trigger Proj. Manage.	0		



Changes since April 2000 Review

- Add design/prototyping of new FPGAs, Optical Links, Backplane (+ $140K)
- Add new task for interface to DAQ (+ $31K)
- Extra manpower for delayed installation (+ $100K)

Cost & Schedule Performance

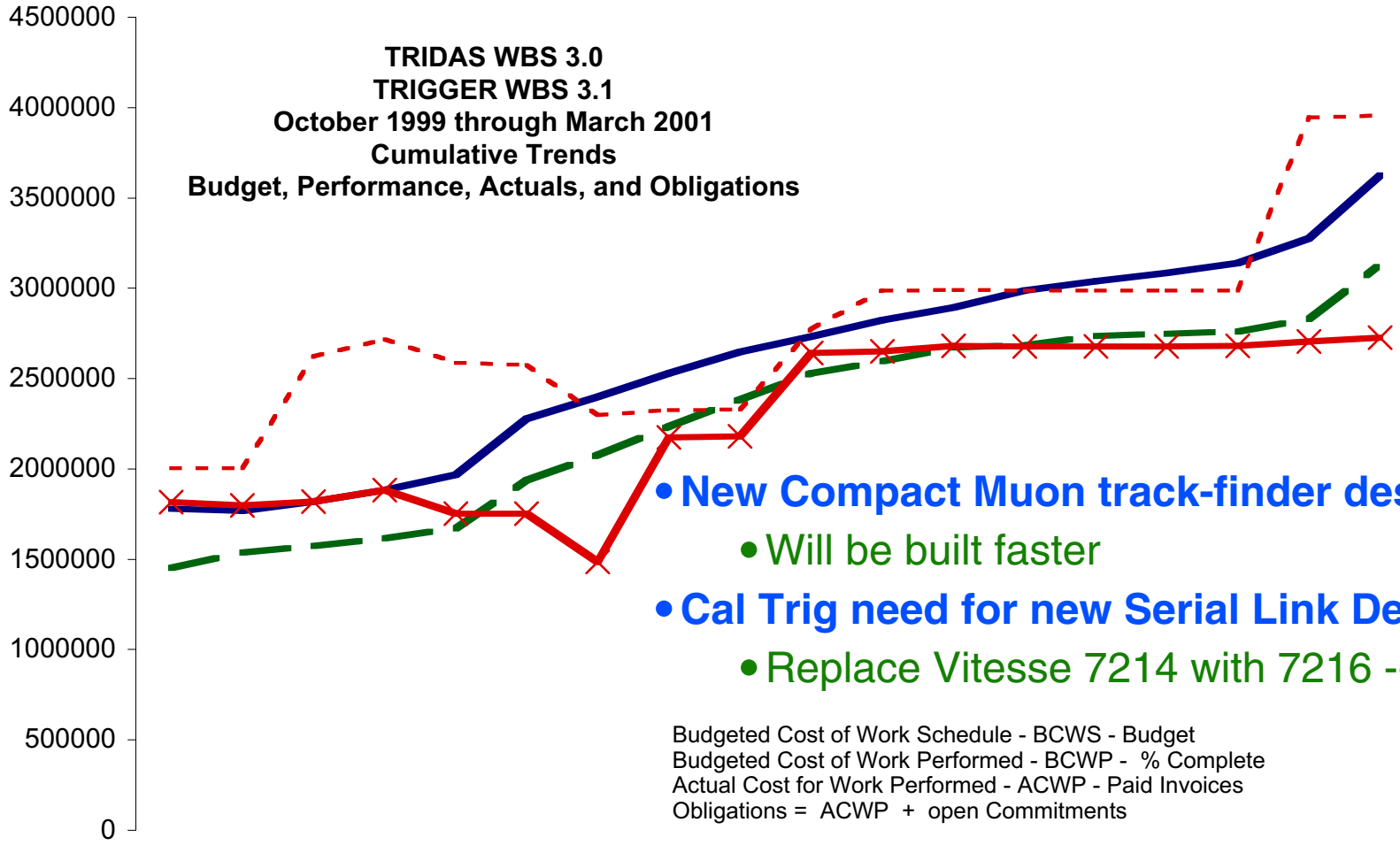
Important revisions result in an improved system

- **Muon Trigger**
  - Combination of Sector Receiver & Processor into one card
    - **Elimination of crate interconnects**
  - Reduction of 6 full crates to one full crate
  - 3 high bandwidth compact links per three muons
  - Faster Backplane technology (GTLP instead of Ch. Links)
- **Calorimeter Trigger**
  - Use of more reliable & stable Vitesse link technology

Consequences for schedule

- **Developments at the expense of schedule for now**
- **Will speed schedule in future**
  - More compact muon trigger -- less to design, build & debug
  - More stable links -- easier to integrate and test

Cost/Schedule Performance

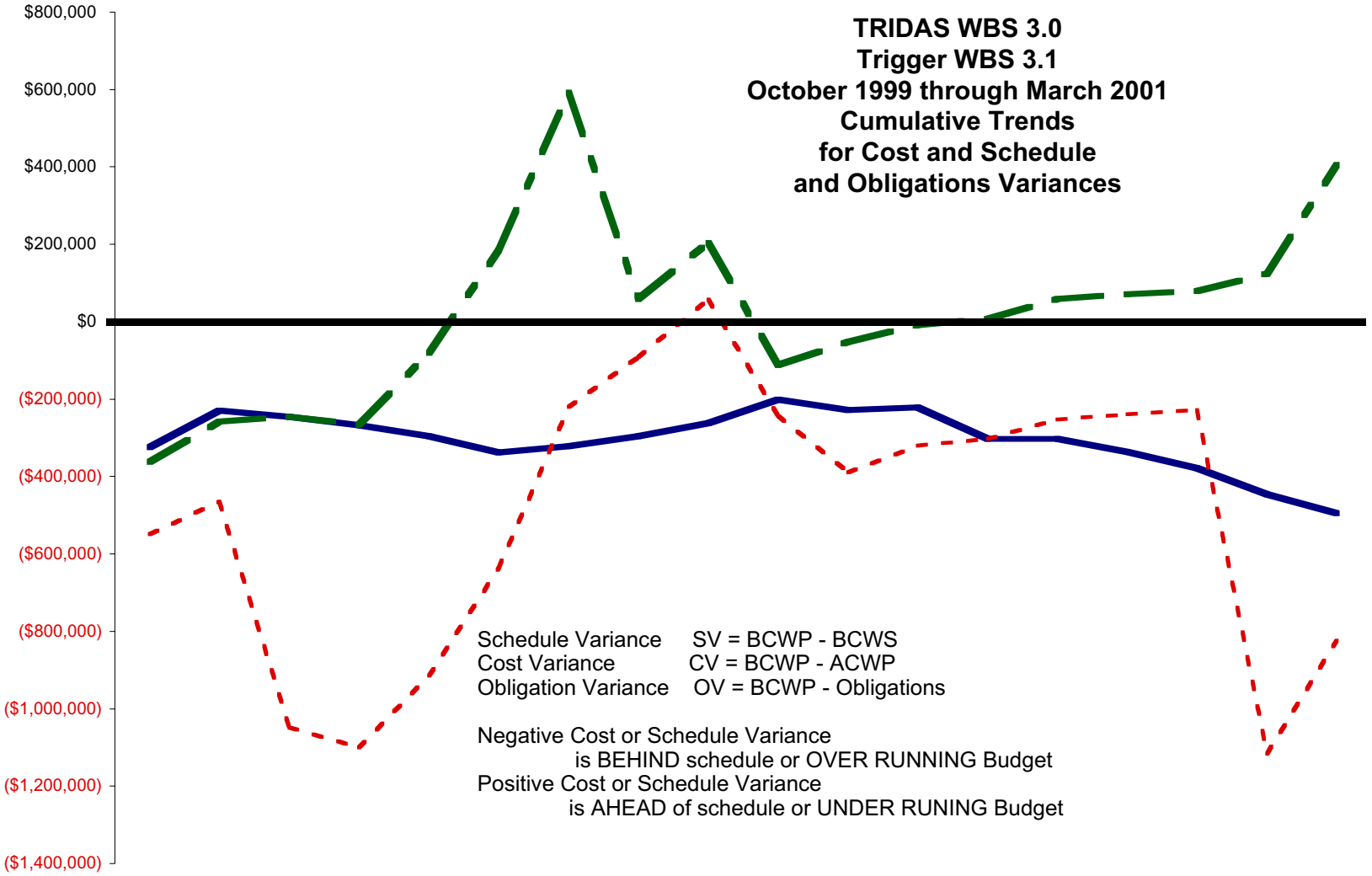


- **New Compact Muon track-finder design**
  - Will be built faster
- **Cal Trig need for new Serial Link Design**
  - Replace Vitesse 7214 with 7216 -- Done

Budgeted Cost of Work Schedule - BCWS - Budget
Budgeted Cost of Work Performed - BCWP - % Complete
Actual Cost for Work Performed - ACWP - Paid Invoices
Obligations = ACWP + open Commitments

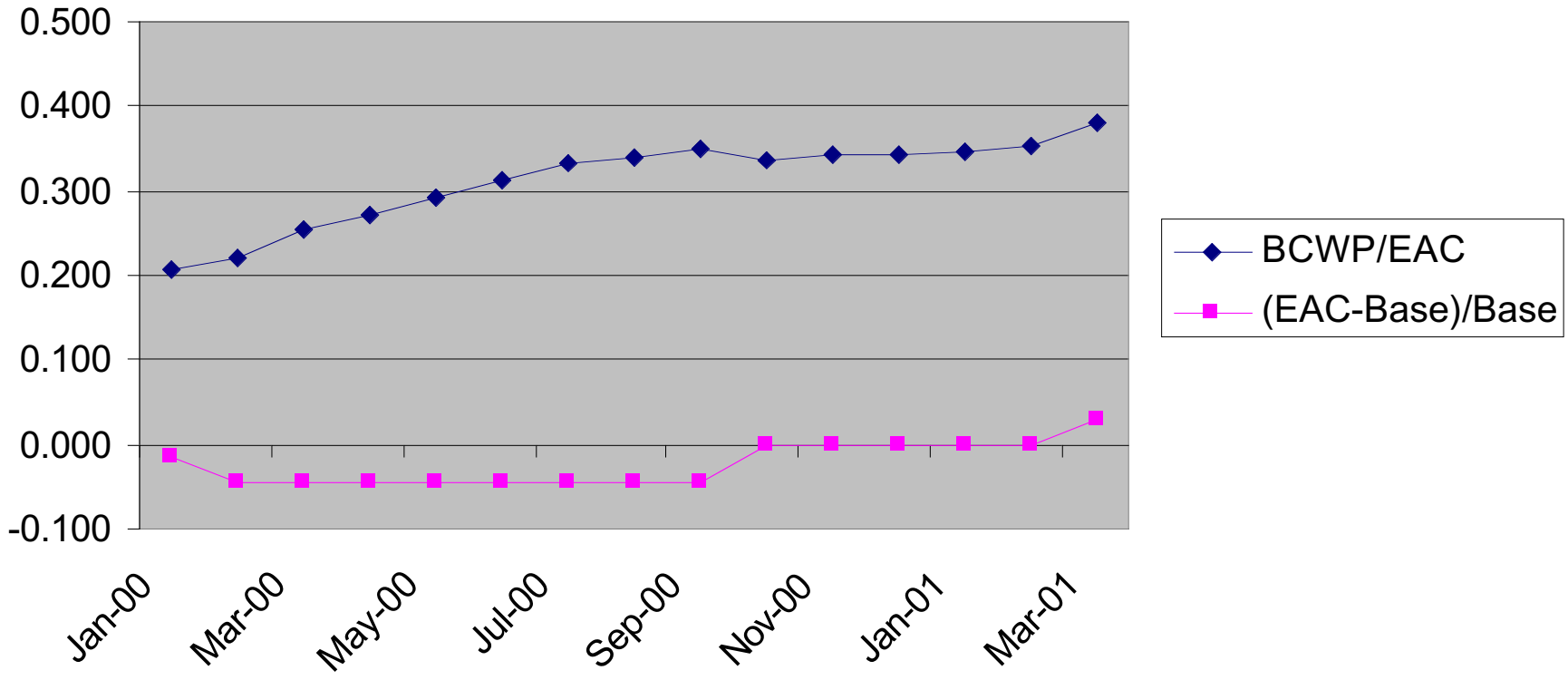
	Oct-99	Nov-99	Dec-99	Jan-00	Feb-00	Mar-00	Apr-00	May-00	Jun-00	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01
BCWS (Budget)	2E+06	2E+06	2E+06	2E+06	2E+06	2E+06	2E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	4E+06
BCWP (Performance)	1E+06	2E+06	2E+06	2E+06	2E+06	2E+06	2E+06	2E+06	2E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06
OBLIGATIONS	2E+06	2E+06	3E+06	3E+06	3E+06	3E+06	2E+06	2E+06	2E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	4E+06	4E+06
ACWP (Paid Actuals)	2E+06	2E+06	2E+06	2E+06	2E+06	2E+06	1E+06	2E+06	2E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06

Trigger Cost/Sched. Trends



	Oct-99	Nov-99	Dec-99	Jan-00	Feb-00	Mar-00	Apr-00	May-00	Jun-00	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01
Schedule Variance	-325042	-229827	-246063	-268131	-296892	-338973	-322455	-297138	-263010	-202427	-228712	-222120	-303027	-303598	-337201	-379831	-446452	-495260
ACWP Variance	-363114	-258489	-246157	-267477	-81515.4	183972	590876	58289.9	203035	-111890	-53440.8	-9681.17	7290.03	57758.6	70606.9	78190.2	123540	404605
Obligation Variance	-550431	-465684	-1048929	-1100431	-915947	-637436	-221466	-92430.1	56449.2	-243349	-390107	-320349	-303378	-252909	-240061	-228381	-1116569	-825077

US CMS Trigger (% Comp., Cont. Use)

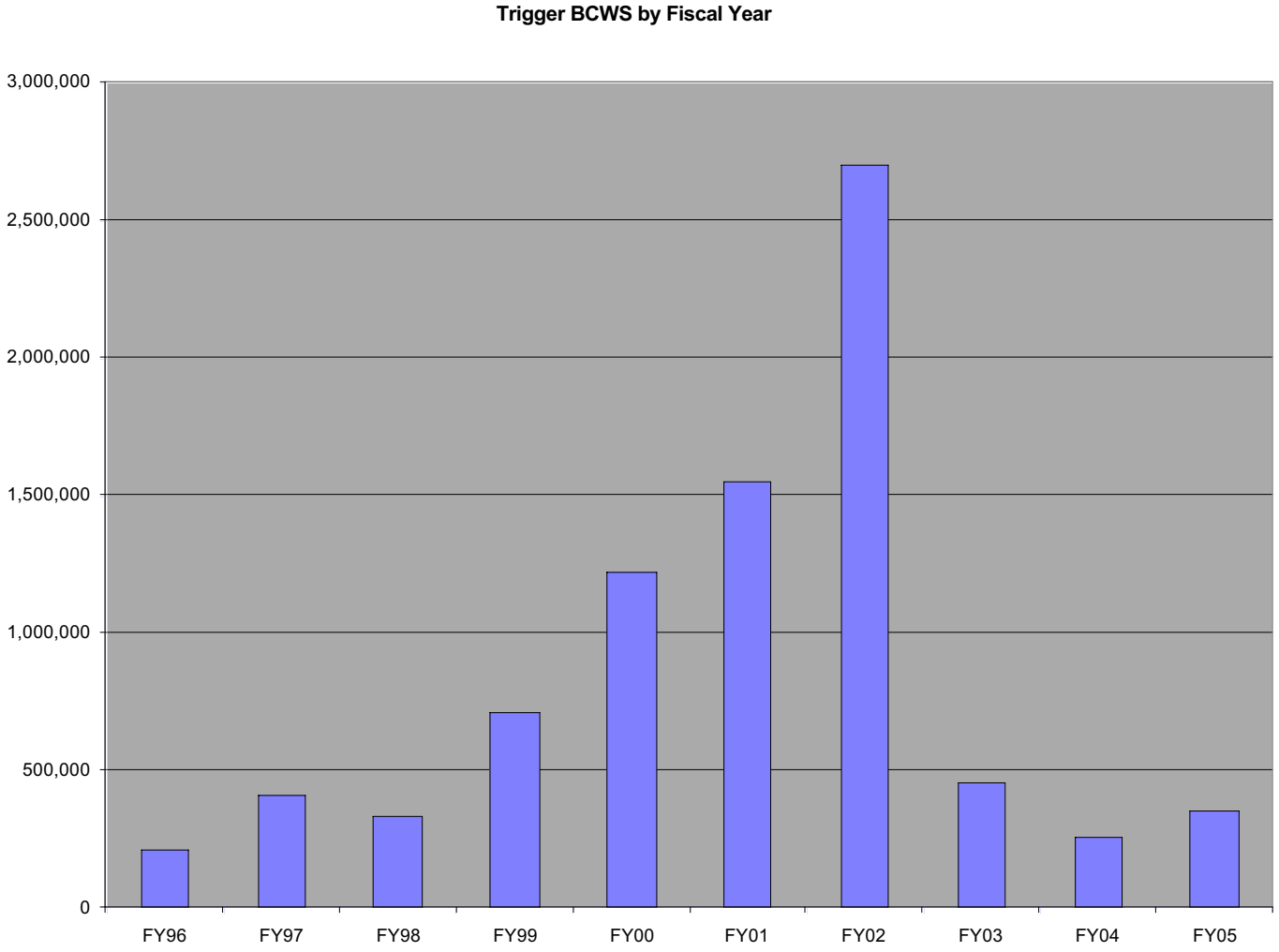


Negligible contingency use thus far

- **Some ASICs purchased early**

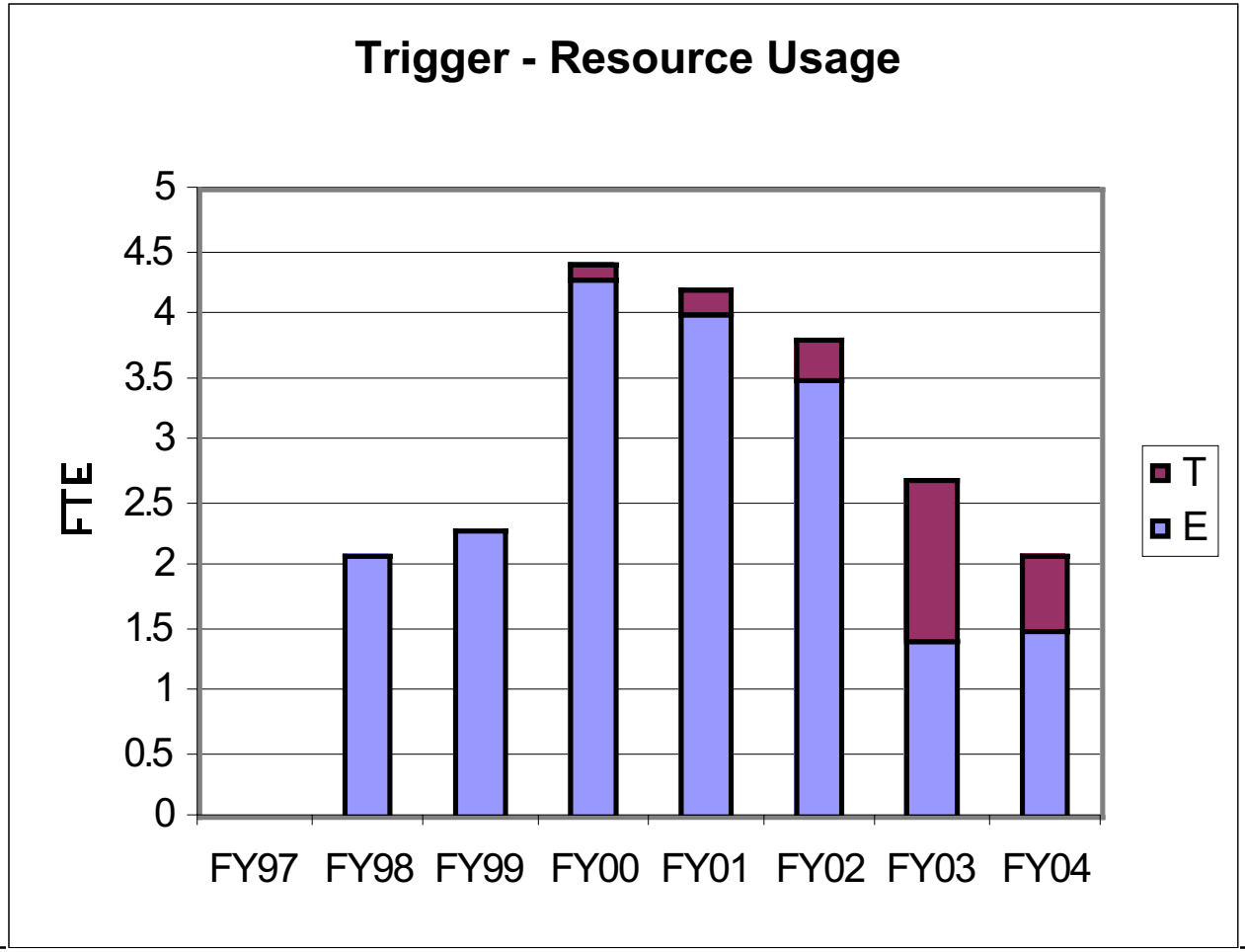
Trigger - Yearly BCWS

Costs ramp up until production, the bulk of which happens in FY02. M&S costs dominate at 65% of the ETC.



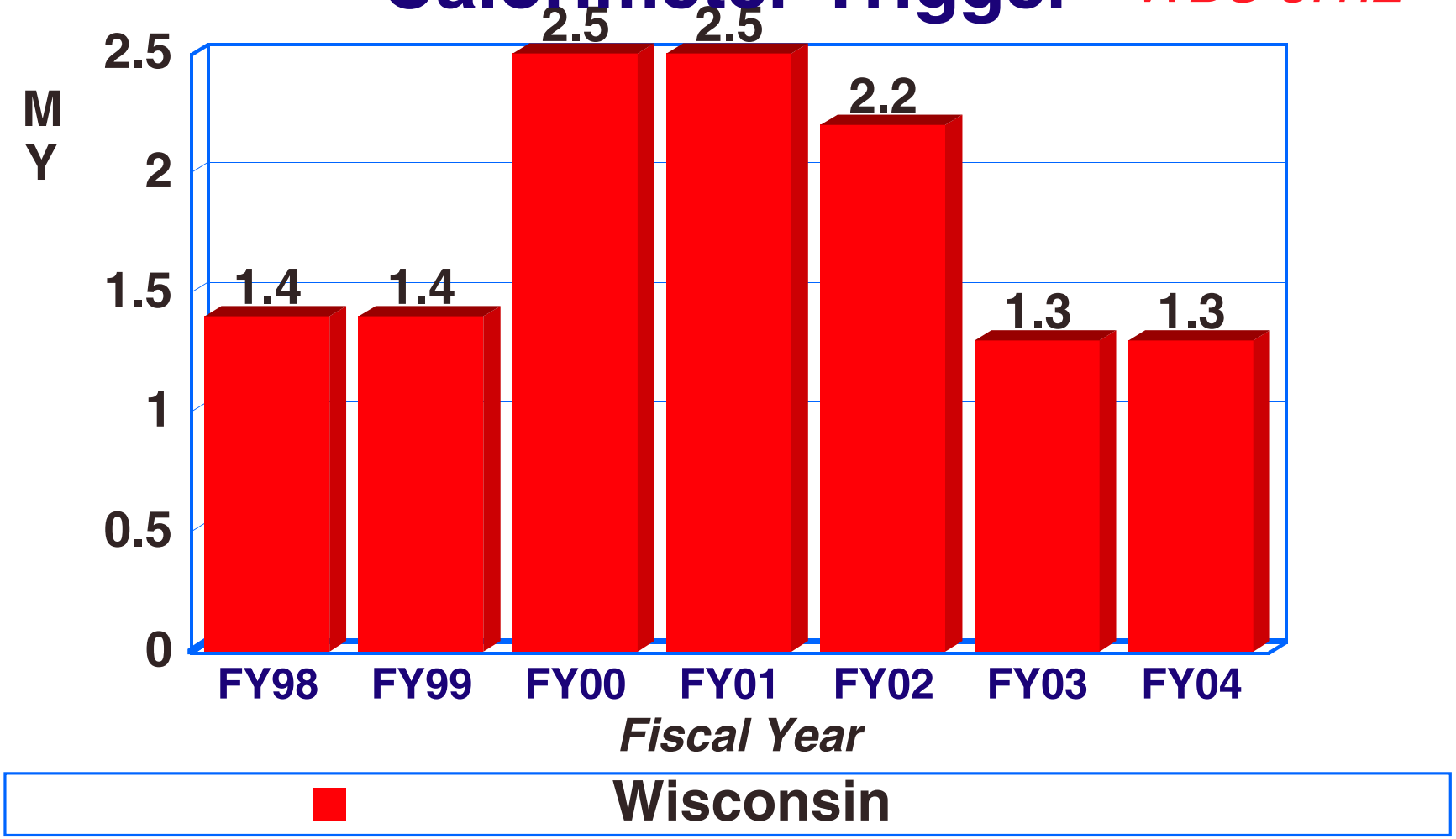
Trigger Resource Usage

Engineering and Technical resources are compared to the people called out in the annual SOW. This tracking ensures that the needed labor is deployed.



Peak Engineering Level

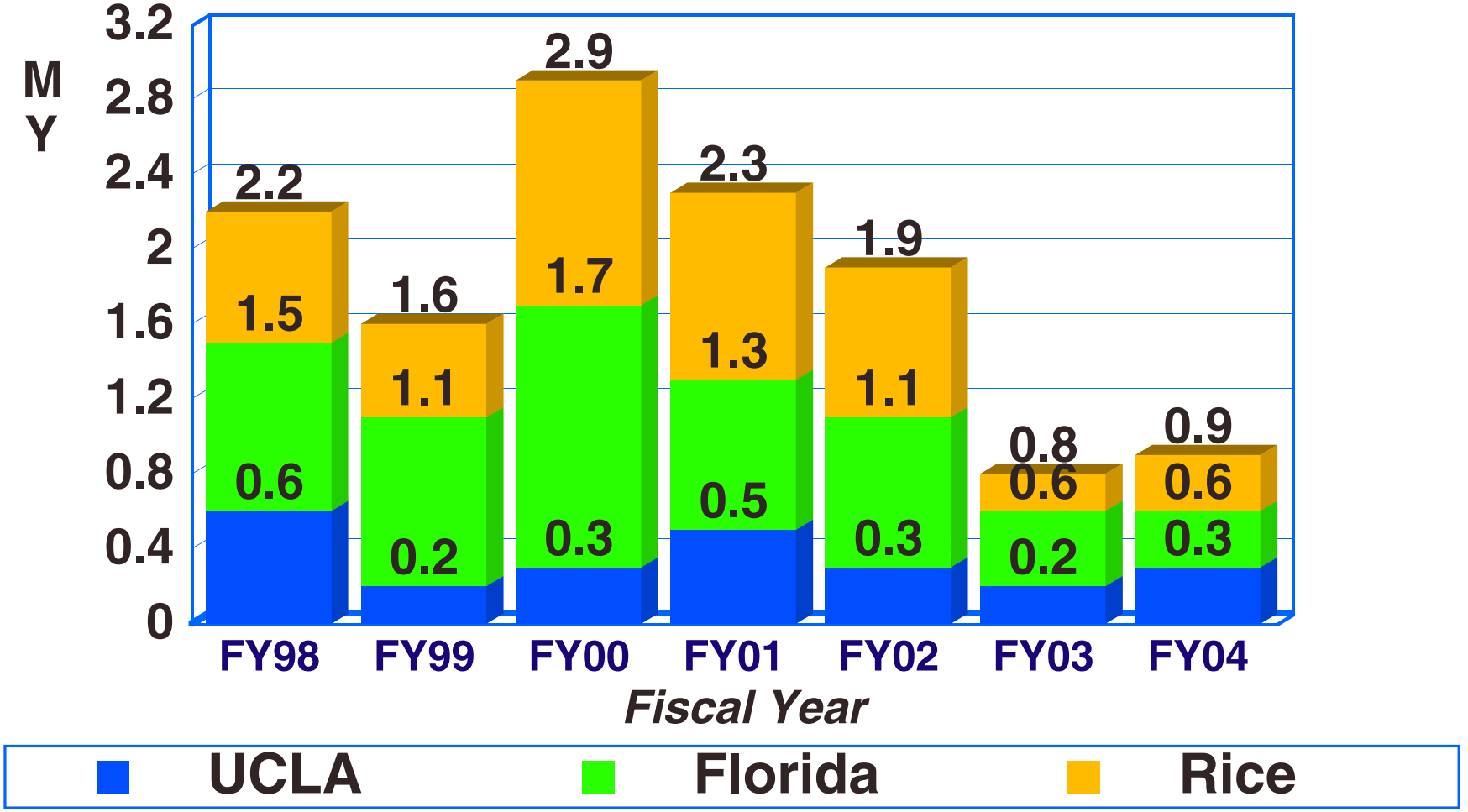
Calorimeter Trigger *WBS 3.1.2*



Peak Engineering Level

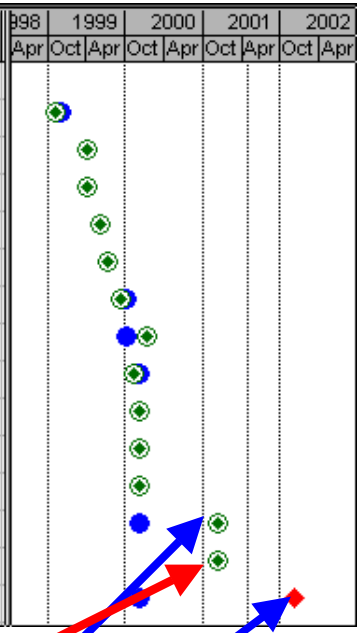
Muon Trigger

WBS 3.1.1



US CMS Trigger
L1, L2, L3 Milestone Performance

System	Level?	CMS ID	Milestone	Variance	Baseline Start	Start
			Trigger System (WBS 1.3.1)	**0 days**	**NA**	**Nov 03 '98**
TRIG	ML2	D-001	Complete Initial Muon, Calorimeter, & Global Trigger Design	-19 days	Nov 30 '98	Nov 03 '98
TRIG	ML3	D-387	CSC: Sector Receiver Initial System Design Document (UCLA)	0 days	Mar 31 '99	Mar 31 '99
TRIG	ML3	D-331	TK: Sector Processor Initial System Design Document (Florida)	0 days	Mar 31 '99	Mar 31 '99
TRIG	ML3	D-388	CSC: Muon Port Card Prototype Design (Rice)	0 days	May 31 '99	May 31 '99
TRIG	ML3	D-390	CSC: Sector Receiver Prototype Design (UCLA)	-1 day	Jun 30 '99	Jun 30 '99
TRIG	ML3	D-332	TK: Sector Processor Prototype Design (Florida)	-22 days	Sep 30 '99	Aug 31 '99
TRIG	ML3	D-389	CSC: Muon Port Card Prototype Delivery (Rice)	59 days	Sep 30 '99	Dec 31 '99
TRIG	ML2	D-002	Complete Phase 1 Prototype Design	-20 days	Nov 30 '99	Nov 02 '99
TRIG	ML3	D-212	Review of Test of Trigger Primitives - 2 Tower Proto Board	0 days	Nov 30 '99	Nov 30 '99
TRIG	ML3	D-221	Review of Test of Regional Trigger - Proto Board and ASICs	0 days	Nov 30 '99	Nov 30 '99
TRIG	ML3	D-240	Review of Calorimeter Trigger Control and Readout Software	0 days	Nov 30 '99	Nov 30 '99
TRIG	ML3	D-231	Design of Final Sort ASIC	251 days	Nov 30 '99	Nov 30 '00
CMS1	ML1	D-004	Submit Trigger Technical Design Report (TDR)	0 days	Nov 30 '00	Nov 30 '00
TRIG	ML3	D-250	Review of Integration of Calorimeter Trigger Prototypes (Palaise	502 days	Nov 30 '99	Nov 30 '01



Comments:

Major L1 Milestone: Trigger TDR on Time!

- **Milestone for SORT ASIC start compensated by faster finish**
- **Integration waiting for ECAL electronics**
- **Extra slack in schedule due to delayed installation**

Level 1 Milestones: 1998-2000

Nov. 1998 Complete Initial Trigger Design ✔

- Algorithms finalized
- Functional blocks determined
- Numbers of ASICs, boards, cards and crates specified
- Interfaces specified
- Trigger geometry determined

Nov. 1999 Complete Phase 1 Prototype Design ✔

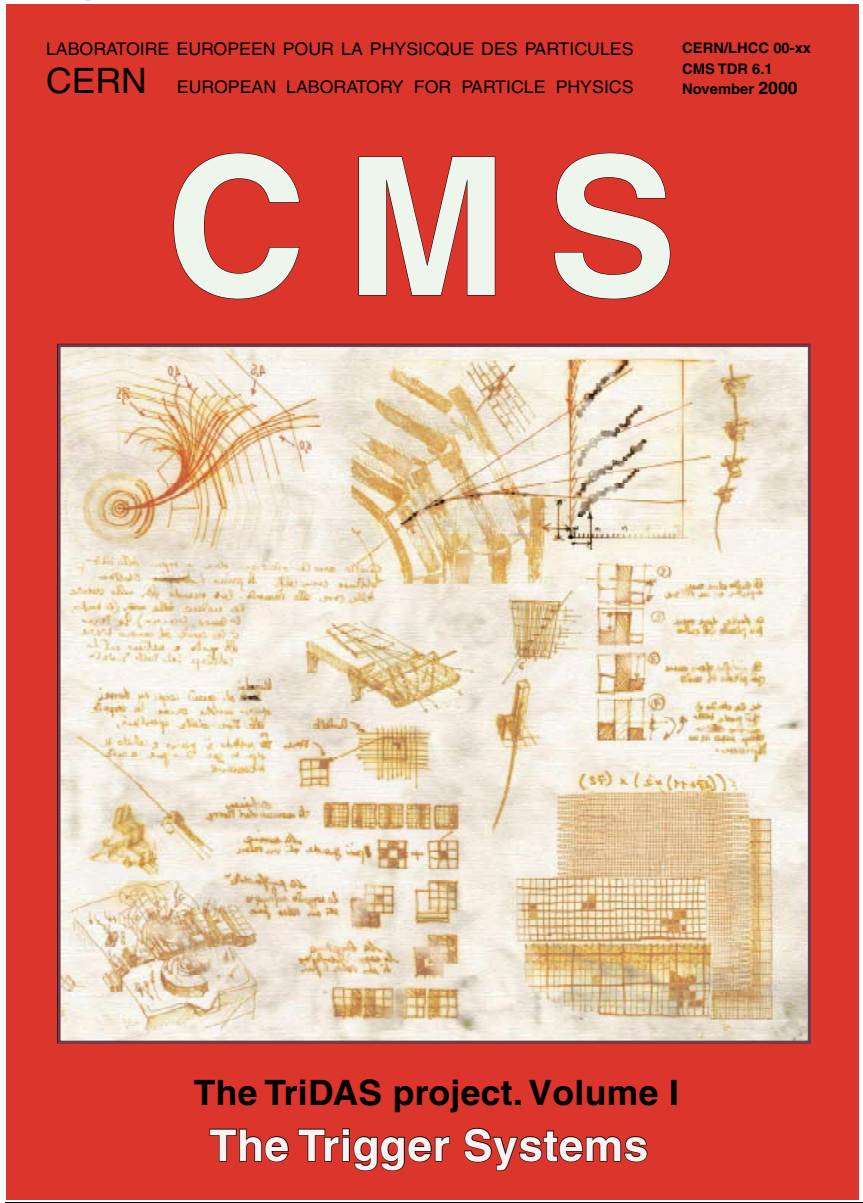
- Designs of boards, cards
- ASICs for prototype tests done

Nov. 2000 Phase 1 Prototype Tests Finished ✔

- All tests necessary to begin design of production electronics are complete

Nov. 2000 Technical Design Report ✔

CMS Level -1 Trigger TDR



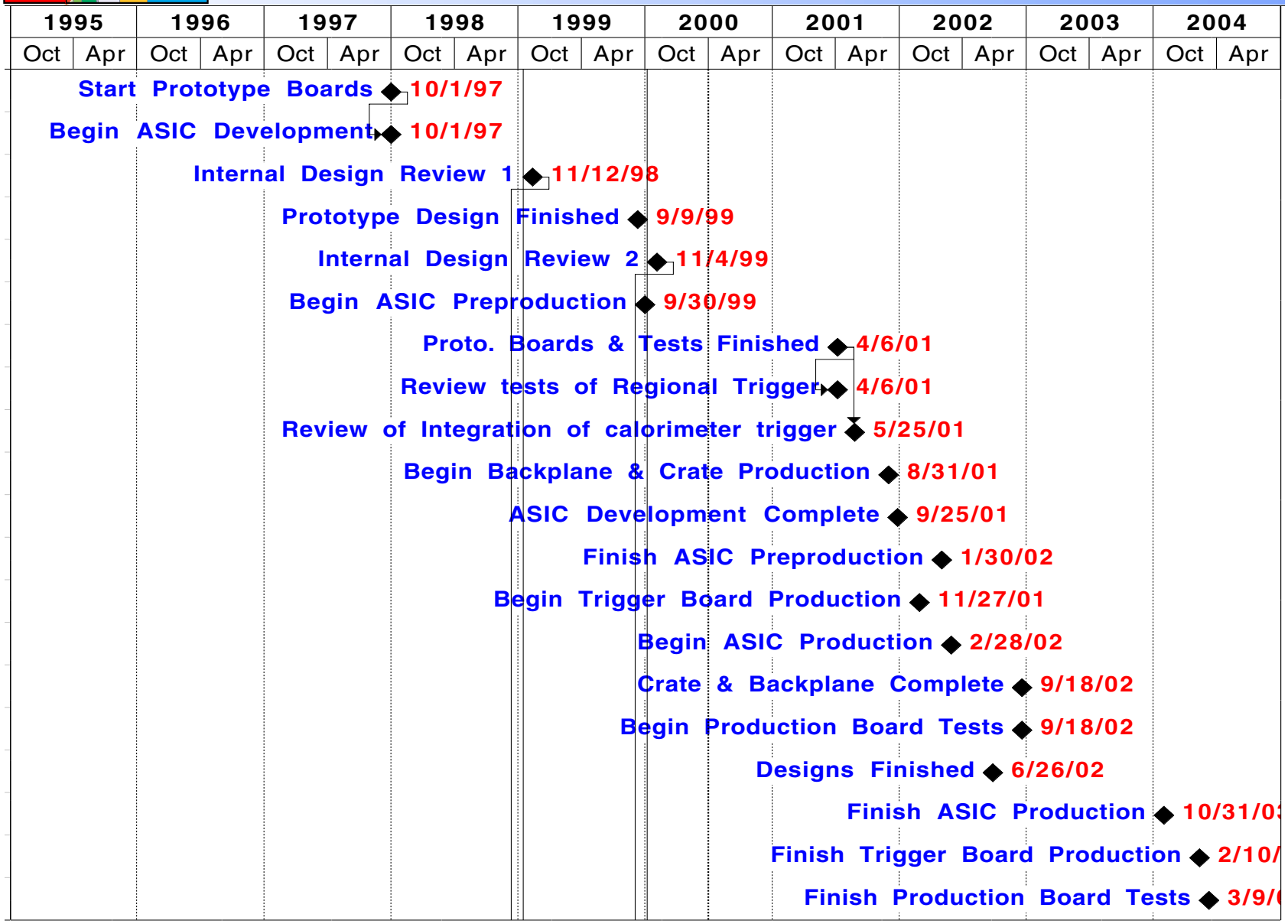
CMS Level 1 Milestone

Submitted to LHCC on Nov. 28, 2000: CERN/LHCC 2000 - 38 CMS TDR 6.1

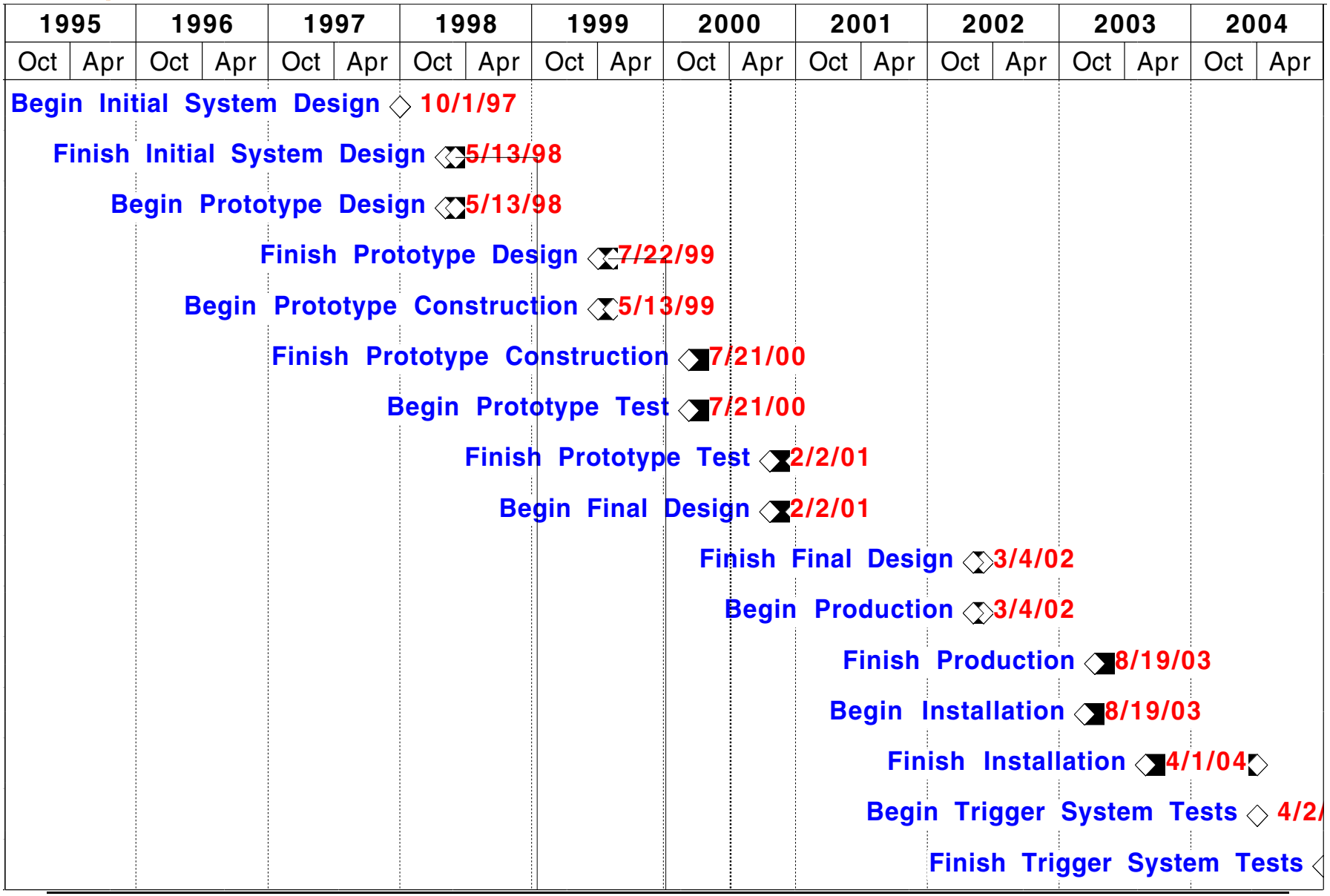
Approved in March, 2001.

http://cmsdoc.cern.ch/cms/TDR/TRIGGER-public/trigger.html

Cal.Trig. - 3.1.2 Milestones



Muon Trig. - 3.1.1 Milestones



Trigger R&D Program

Summary

- Engineering evaluation & prototyping to evaluate design capability, feasibility, and cost.
- Goal is to provide the information required for the subsystem trigger designs and specifications of interfaces to the Front End, Trigger and DAQ systems.
- Phase 1 prototyping program designs were complete November 1999 and tests will be complete and fully reported on by November 2000. Final result of this program wasthe Level-1 Trigger Technical Design Report in 2000.
- Phase 2 prototyping program is concentrating on final or pre-production prototypes based on the design in the TDR.

Trigger Program

Simulation

- Check detector changes effect on trigger performance
- Validate final algorithms as implemented in hardware

Calorimeter Trigger

- Validate 160 MHz dataflow & processing
- Design & test prototype Boards
- Design & test prototype ASICs
- Design & test high speed Cu serial Link system

Muon Trigger

- Design & test prototype Boards
- Design & test prototype FPGA circuits
- Design & test high speed optical serial link system
- Test interface with CSC FE electronics

Cal. Trigger Status & Plans

Test Prototypes

- New Proto.160 MHz Backplane - manufactured
- New Proto. Receiver Card - in layout
- New Proto. Clock Card - being manufactured
- New Proto. Electron ID Card - in design

Serial Data Tests

- New Serial Link Test Card - in design
- New Serial Link Mezzanine Card - in layout

ASIC PrototypeTests

- All Prototype ASICs tested by Vitesse & Delivered
- Phase & BSCAN will test on Receiver Card
- SORT & Electron ID will test on Electron ID Card

Integration Tests

- Serial Link Test Card & Mezzanine Card w/ ECAL

Muon Trigger Status & Plans

Compact Muon Trigger Design

- **Single Sector Processor FPGA**
  - Verified can be done with a single Xilinx 1600E
- **New Backplane**
  - GTLP tested at 80 MHz
- **Higher bandwidth and more compact optical links**
  - TI TLK 2501 tested at 80 MHz parallel I/O
- **Technical Review on May 24**
  - Outcome: plan & sched. for final design & protos.

New Prototypes

- **Muon Port Card proto. with new optical links**
- **Combined Sector Receiver/Sector Processor proto.**
- **Proto. Backplane based on GTLP**

Trigger Project Management

CMS TriDAS Reviews (besides this)

- **April: TriDAS Status**
  - Progress, draft R&D plans & expenses for next year
- **May: Electronics Systems Review**
- **September: CMS Annual Review**
  - With CMS & external referees
- **October: LHCC Comprehensive Review**
  - LHCC subcommittee +external experts
- **November: TriDAS Annual Review**
  - R&D Plans/Progress, Cost & Schedule, Milestones
  - Finalize R&D plans & expenses for next year
  - Internal Annual CMS Review w/external & CMS referees

Trigger Project Management

US CMS Management

- **US Reviews**
  - Monthly Video Conferences
  - Florida, Rice, UCLA, Wisconsin
  - Review Progress, milestones, simulation activities
- **US Reporting**
  - Monthly progress reports:
    - **% complete**
    - **activities narrative**
- **US Integration Meetings:**
  - Calorimeter Trigger: FNAL, Maryland, Wisconsin
  - Muon Trigger: Ohio, Florida, Rice, UCLA, Wisconsin, others.
- **US Trigger Site Visits: Florida, Rice, UCLA**

Conclusions - Trigger

Good Progress Since April 2000 Lehman Review

- **Extensive prototyping & test program**
  - "Proof of principle" of all critical items
  - Number of successes already
    - **CSC trigger integration test, New Optical Links, Backplane, FPGA**
    - **Calorimeter trigger Receiver & Electron Cards, Backplane, ASICs**
- **Cost & Schedule Performance**
  - All Milestones made
  - BWCP/BWCS at 85%
    - **In good shape**
    - **Compact muon trigger simpler -- will improve**
    - **Prototype Calorimeter ASICs all in hand ahead of original schedule**
- **Project Management**
  - Extensive system of reviews and monitoring in place
    - **TDR done, detailed documentation on WWW: http://cmsdoc.cern.ch/ftp/afscms/TRIDAS/html/level1.html**