Forward Pixels – Project Status and Baseline Proposal

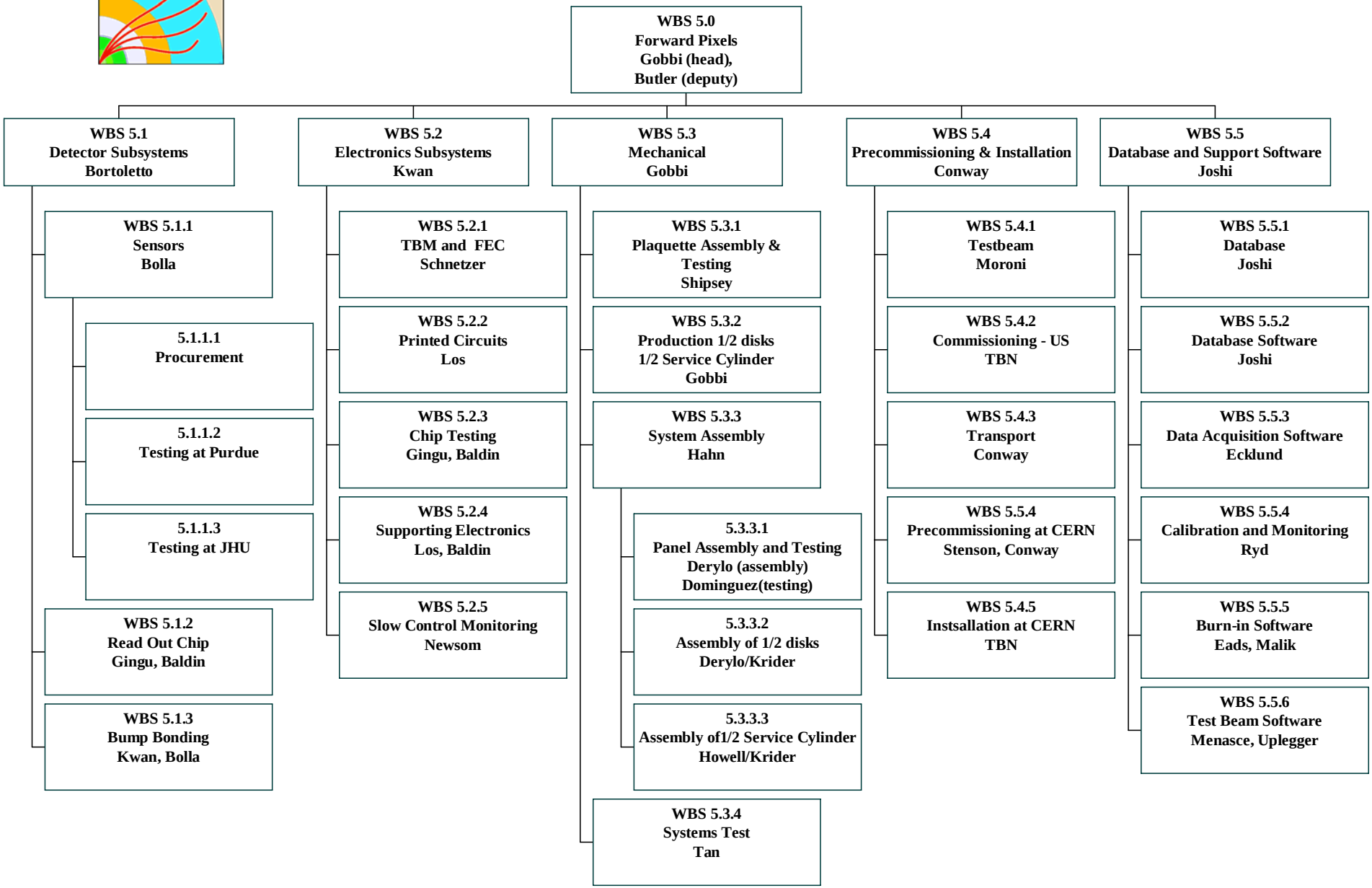
USCMS FPIX Technical PMG

Joel Butler

September 29, 2006

Outline

- WBS and Organization Chart
- Status and Remaining Work
- Division between M&O and Construction and the ’07 run
- Schedule and cost
- Contingency Analysis
- Summary and baseline request


WBS 5.0
Forward Pixels
Gobbi (head),
Butler (deputy)
WBS 5.1
Detector Subsystems
Bortoletto
WBS 5.2
Electronics Subsystems
Kwan
WBS 5.3
Mechanical
Gobbi
WBS 5.4
Precommissioning & Installation
Conway
WBS 5.5
Database and Support Software
Joshi
WBS 5.1.1
Sensors
Bolla
5.1.1.1
Procurement
5.1.1.2
Testing at Purdue
5.1.1.3
Testing at JHU
WBS 5.1.2
Read Out Chip
Gingu, Baldin
WBS 5.1.3
Bump Bonding
Kwan, Bolla
WBS 5.2.1
TBM and FEC
Schnetzer
WBS 5.2.2
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Chip Testing
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WBS 5.2.4
Supporting Electronics
Los, Baldin
WBS 5.2.5
Slow Control Monitoring
Newsom
WBS 5.3.1
Plaquette Assembly &
Testing
Shipsey
WBS 5.3.2
Production 1/2 disks
1/2 Service Cylinder
Gobbi
WBS 5.3.3
System Assembly
Hahn
5.3.3.1
Panel Assembly and Testing
Derylo (assembly)
Dominguez(testing)
5.3.3.2
Assembly of 1/2 disks
Derylo/Krider
5.3.3.3
Assembly of1/2 Service Cylinder
Howell/Krider
WBS 5.3.4
Systems Test
Tan
WBS 5.4.1
Testbeam
Moroni
WBS 5.4.2
Commissioning - US
TBN
WBS 5.4.3
Transport
Conway
WBS 5.5.4
Precommissioning at CERN
Stenson, Conway
WBS 5.4.5
Instsallation at CERN
TBN
WBS 5.5.1
Database
Joshi
WBS 5.5.2
Database Software
Joshi
WBS 5.5.3
Data Acquisition Software
Ecklund
WBS 5.5.4
Calibration and Monitoring
Ryd
WBS 5.5.5
Burn-in Software
Eads, Malik
WBS 5.5.6
Test Beam Software
Menasce, Uplegger

Target Production Rates

- Production rate is driven by demonstrated ability of Purdue to produce 6 plaquettes/day
  - Requires laminated, stuffed, diced VHDIs from FNAL, which is now a solved problem
- This supports production of eight completed panels/week
  - Requires laminated, stuffed HDIs with a TBM mounted. Then, we have to mount the 3 or 4 plaquettes, do the wire bonding, and test the finished panel. We can do 2/day. So far, have done equivalent 10% including for '07 run. Taking extra time to evaluate Plaquette grading
- We need 192 panels and want 10% spares
- large clean room, Lab C N(11m x 11 m), at SIDET is set up for assembly and testing of a half-rings and half-cylinders, with all assembly stations up and running
- We should be able to assemble a half-ring in a few days. There are 8 half-rings. First attempts will allow us to improve our relatively simple tooling. Even our first attempts indicate that we can do it in less than a week, which would be perfectly acceptable
- First experience with half-cylinders will be in the next two weeks. We have already fitted a mockup-half ring into the half-cylinder for '07 Run

Remaining Design Work

- **Mechanical (see Joe Howell's talk)**
  - Cooling manifolds
  - Miscellaneous small parts for cooling system and service cylinder
  - Installation fixtures (can start after ~Jan 1, '07)
  - Shipping container for '07 detector (needs attention soon)
- **Electronics (see Simon Kwan's talk)**
  - HDI – 3L design (completed yesterday – will submit ASAP)
  - CCUM
  - Adapter Board (+ Z versions)

Final Assembly and Testing at SIDET and CERN

- **Just starting to develop procedure**
  - Can read half-rings out with existing PTA hardware and Renaissance software
  - Will read out with CMS Data Acquisition gear from our system test. We will have enough software to make sure that we can do a pixel alive test and other basic tests.
  - After acceptance, will disassemble and send to CERN
  - At CERN, we will check out the half-rings in the upstairs clean (PIC) room in Building 186
  - Then we reassemble the half rings into the half-cylinder and test again
    - There will be a team in residence at CERN to do this
  - We will store the half-cylinder in Building 186 until it is time to move to Point 5. Could decide to do a final test depending on schedule in the fall of '07
  - We have procured most of the necessary equipment for Building 186 and will ship it at the end of November
    - The team will arrive at that point and set it up
  - We are beginning to design installation fixtures. Checked for interference in mockup test at CERN in June

Transportation and Installation

- For transporting to CERN, the half-rings will be removed and the half-cylinder shipped by airplane
- The half-rings will probably be carried on the plane by physicists in specially prepared cases
- The cost of this is accounted for
- The half-cylinders are light, ~20 Kg not counting the cable pigtails
- The installation fixturing is relatively simple. We have a conceptual design and some drawings that are the basis of cost estimates. CMS integration is providing the actual supports and insertion rails. We have already tested these in a mockup trial at CERN in June ’06. Final design and procurement has yet to be done
- Transportation and Installation are considered low cost and low risk, but of course an accident would have devastating impact!

FPIX ’07 Commissioning Run

Current plan

- Forward: ~30 degree azimuthal coverage in two disks on one side of the IR (e.g. positive η)

Our Goals Relevant to the Construction Project:

+ To test all aspects of the half-ring and half-cylinder assembly and testing

+To gain as much experience in installation, hookup, testing and commissioning in ’07 as possible so that we can do things very efficiently in ’08 for full detector

+ To establish the infrastructure at CERN to commission and maintain the production detector

Boundary Conditions: Do only tasks that we had to do anyway

- By doing them earlier, there is still time to correct problems
- Limited to pre-production components that would have been made anyway. These are not included in the final detector or in the “operational spares” count, so the experiment will not suffer if a machine upset causes damage.

Do not increase the costs of the Construction Project (use M&O funds) or delay it (use the new people)

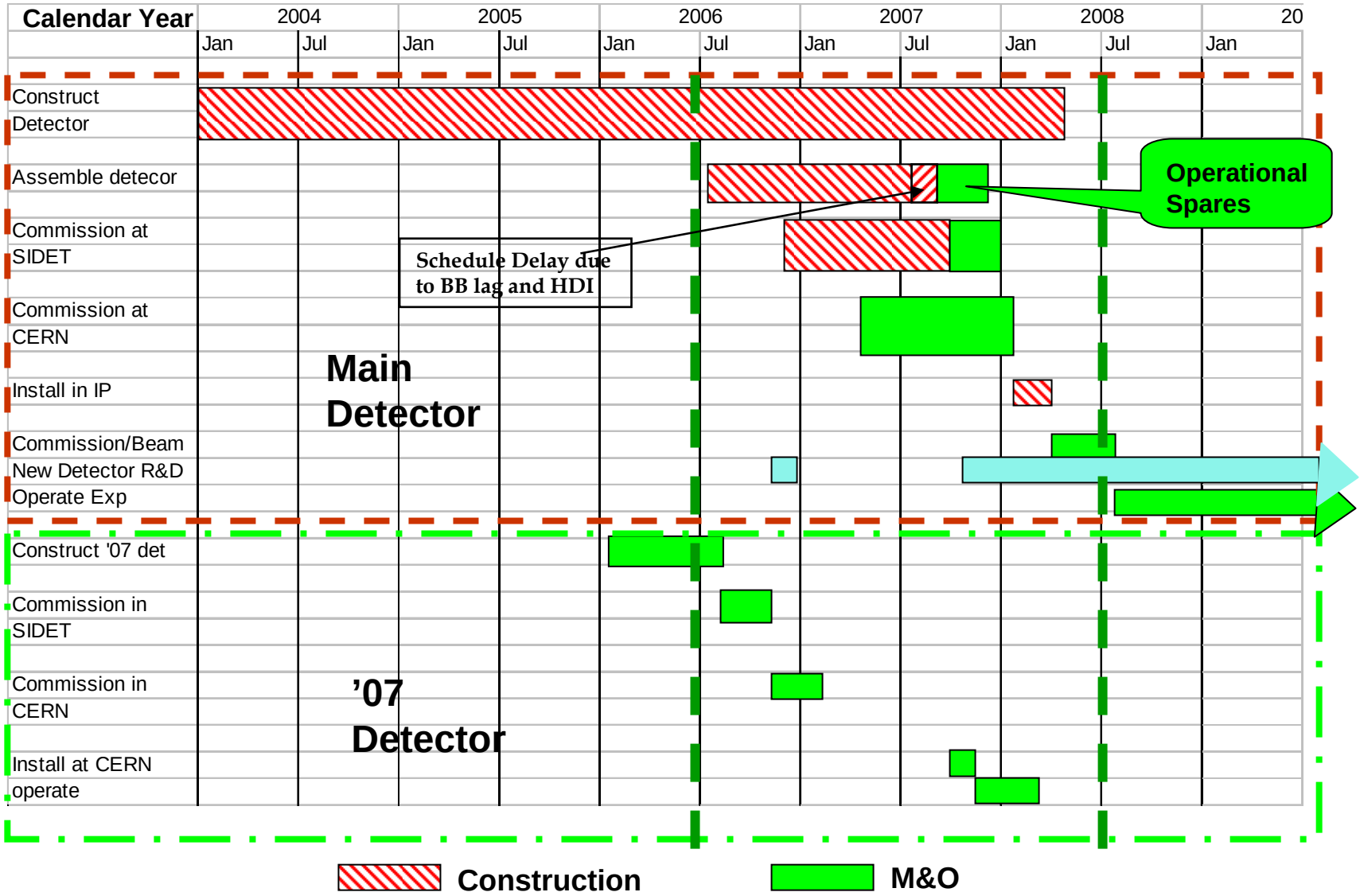
Plans for ’07 Run

- All 8 panels produced
- “Half-ring” (partially populated) being assembled and tested
- Preparing assembly/test-stand for half-cylinder assembly
- Four groups have agreed to work on establishing the infrastructure at CERN for commissioning and installing the ’07 system
  - University of California, Davis
  - University of Colorado
  - University of Milan
  - University of Iowa
- We have procured materials for Bldg 186 and will ship it in November. People will show up to install it then
- Others will follow as they complete their tasks and as work at SIDET begins to wind down

Key Milestones

Resumption of Bump-bonded module deliveries	Oct ’06, week 4
Completion of first two disks of cooling channels	Oct 30, ’06
Arrival of HDI 3LX	Est. Nov 6, ’06
Completion of first half-ring	Dec 1, ‘06
Completion of first Half-cylinder and shipment to CERN	Jan 15-30, ‘07
Completion of installation fixturing design	Est. Jan ‘07
Completion of bump-bonding order	April-May ‘07
Completion and testing of Installation fixturing	Est. June ‘07
Completion of last half-cylinder and shipment to CERN	Aug ‘07

Schedule: From Construction to M&O

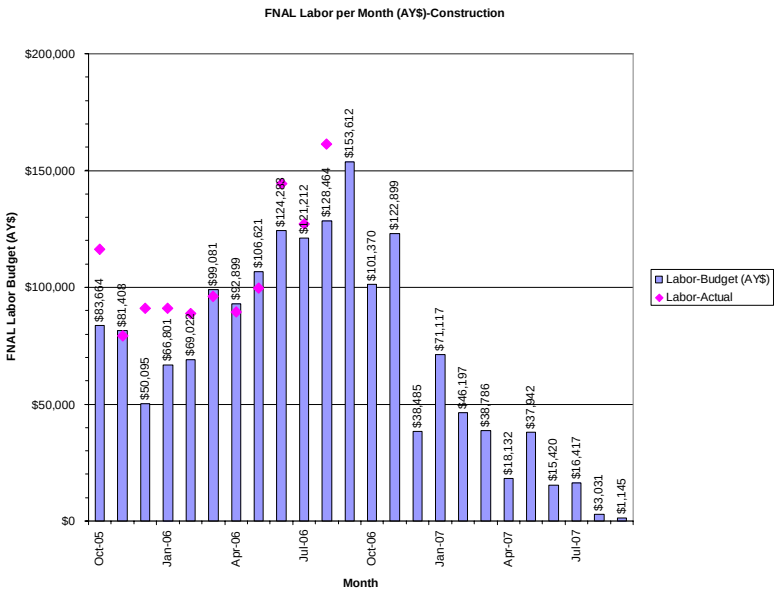


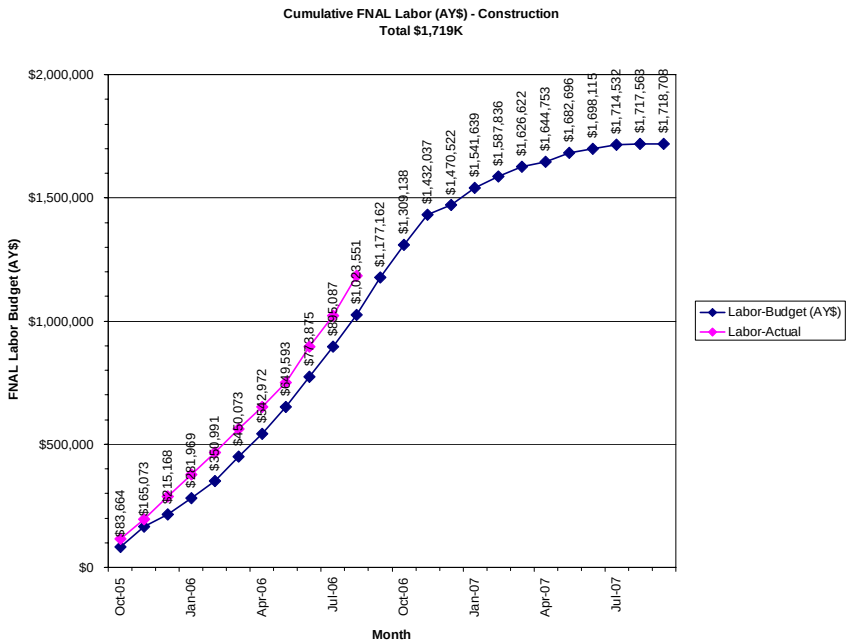
Cost to Complete from Oct. 2005 (w.o. Contingency)

WBS #	Title	Total Cost	Cost on DOE Construction
5.(2)1	Detector Subsystems	1,146K	$981K
5.(2)2	Electronics Subsystems	1,120K	$1,119K
5.(2)3	Mechanical/Assembly	2,015K	$1,972K
5.(2)4	Pre-commissioning and Installation	238K	$131K
5.(2)5	Database and Software	201K	$0.0K
5 (Total)	Total	4,720K	$4,155K

The cost to complete the FPIX Project from Oct 2005 is $4.72M, of which $4.20M comes from the Construction Project and $0.52M comes from the M&O Project. We actually budgeted $0.6M from M&O. We claimed we needed a contingency of $0.78M. Almost all M&S expenditures are coming in very close to expectations. Overall, we are about ½ spent if we include the full cost of bump bonding. Mechanical parts are still to come and may overrun some.

Labor





Status of ’06 SOWs:

1. **Purdue done**
2. **KSU done**
3. **Rutgers done**

’07 SOWs:

Mainly Purdue $155K

University groups are delivering on cost and schedule

Costs are actually Construction + M&O. We are over our Construction estimate by $160K. However, in September we have moved $125K to M&O for ’07 run and spares so the variance will be reduced to $35K. Main overruns due to VHDI and IZM “crises”

Contingency Analysis
Bump Bonding

- **Bump-bonding yield**
  - **We had a windfall and wound up with 20% more good sets of sensors**
    - We can also buy 8 more sets at $2500/set (immediate delivery) for $20K
  - **We will have enough readout chips to populate them**
  - **We have reordered enough VHDIs to populate them**
  - **Bump-bonding them is the only major expense. It is covered in our 20% option. It would cost $150K and perhaps $50K of labor.**

Labor Contingency

- **We have been using more engineering and less technician labor than expected but we have been within 1/2 FTE**
  - **If the project were to stretch out for a few months or we needed to use overtime to make up for lost time, we could incur additional labor costs.**
    - Estimate that 1 engineer for 4 months and 1 FTE year of technician time (2 technicians for 6 months) would be adequate
    - Cost would about $150K on a base of about $600K to go (an additional $125K labor will be charged to M&O)

Installation Contingency

- It is not easy to understand installation costs at CERN.
  - Some of our installation, e.g. cables & connectorization, will be included in larger installation contracts
  - Some changes are occurring even at this late date – e.g. introduction of a new intermediate patch panel (imposed on us by tracker management)
  - Some costs that were expected to be absorbed by CERN or CMS might be passed on to us
- Installation costs are estimated at $100K. Given uncertainty, include 100% contingency.

Overall need for contingency is $470K, half of cost only if IZM problem continues.

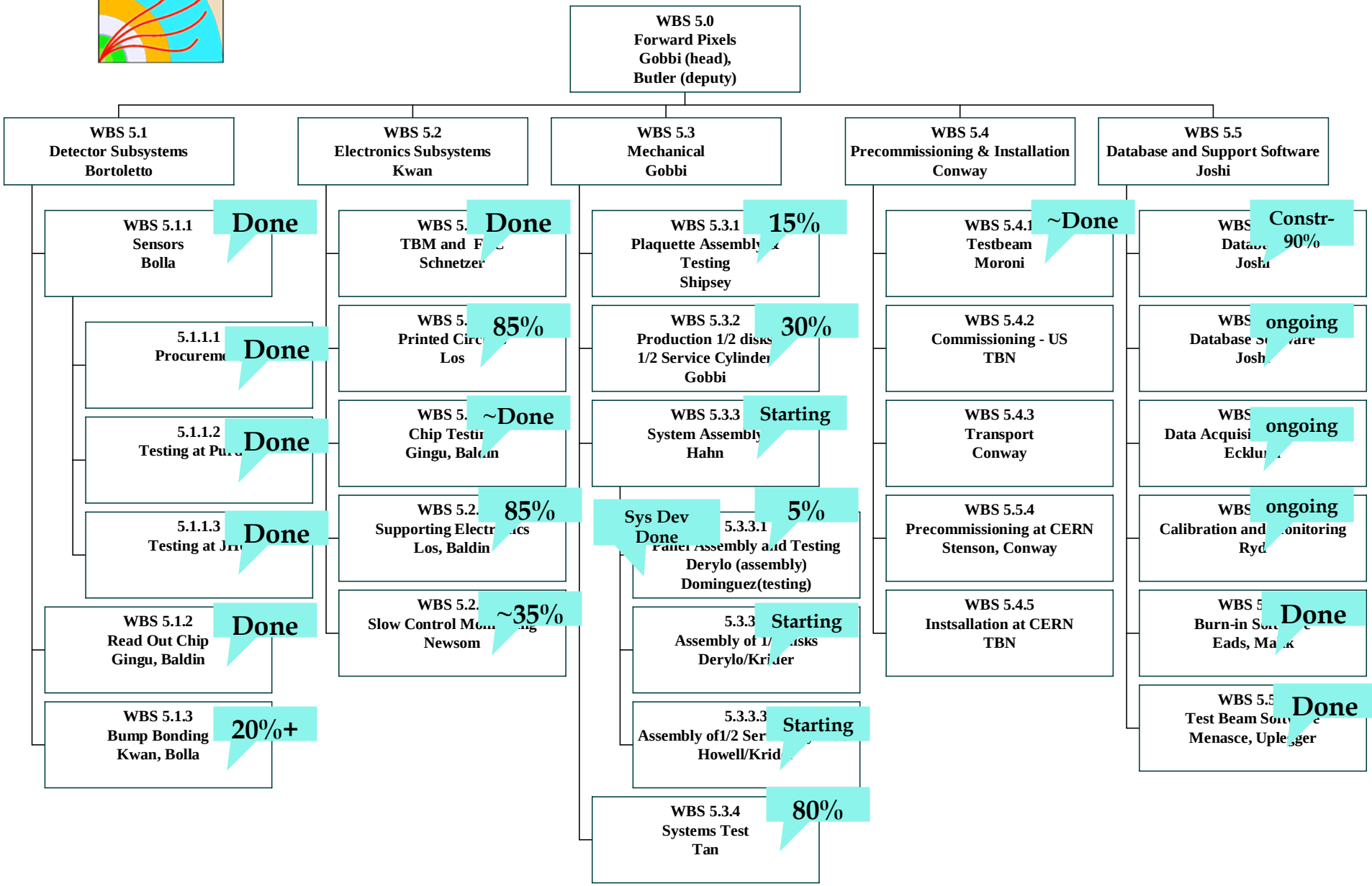
Technical

Table of Parameters

1. 16 Million pixels
2. Four half-cylinder, two on each side of beam on each end of IP
3. 2 half-disks in each half cylinder
4. 99% average tracking efficiency (test beam)
5. 15 micron resolution (test beam)
6. Able to survive $6x10^{14}$ fluence (Indiana Cyclotron and test beam)

Cost

	Base Cost	Cost to Complete	Cont.	% Cont/CTC	Total
Pixels	12.0M	2.2M	$480 K $780 K	22% 35%	$12.48M $12.78M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Sensors
Bolla
Done
5.1.1.1
Done
5.1.1.2
Done
5.1.1.3
Done
WBS 5.1.2
Read Out Chip
Gingu, Baldin
Done
WBS 5.1.3
Bump Bonding
Kwan, Bolla
20%+
Done
85%
~Done
85%
~35%
WBS 5.3.1
Plaquette Assembly
Testing
Shipsey
15%
WBS 5.3.2
Production 1/2 disks
1/2 Service Cylinder
Gobbi
30%
WBS 5.3.3
System Assembly
Hahn
Starting
Sys Dev
Done
5%
Derylo (assembly)
Dominguez(testing)
Starting
Starting
WBS 5.3.4
Systems Test
Tan
80%
WBS 5.4.1
Testbeam
Moroni
~Done
WBS 5.4.2
Commissioning - US
TBN
WBS 5.4.3
Transport
Conway
WBS 5.5.4
Precommissioning at CERN
Stenson, Conway
WBS 5.4.5
Instsallation at CERN
TBN
Constr-
90%
ongoing
ongoing
ongoing
Done
Done

Management

- Adequate Staff at Purdue to successfully complete on schedule.
- Adequate staff at SIDET to complete successfully on schedule
- Supply of physicist labor is committed and adequate to the task
- Appropriate Management Organization in place to complete successfully on schedule and within costs.

Summary – Technical Status

- **We have started production**
  - **Key subassembly, bump-bonded module, is 15-20% complete, and contracts are in place to do the remainder**
  - **Key production rates have been established and maintained for significant periods of time**
    - Assembly of 6 plaquettes/day at Purdue
    - Burn-in and testing of 6 plaquettes/day at FNAL
    - Assembly of 8 panels/week at FNAL
- **Remaining electronics design >90% done and most components procured and tested**
- **Assembly of half-rings and half-cylinders beginning now with ’07 module, which will allow us to debug these steps**
- **Final design and fabrication of installation fixtures yet to go. A conceptual design exists**
- **We plan to finish in August of ’07. Need to have system at CERN and ready to install by early January ’08.**

Summary – Cost and Schedule

M&S costs are now quite well-understood. Most components have already been procured

Labor costs are well-understood and we are managing them successfully

A top-down contingency estimate, given above, is for about $470K (as opposed to previous estimate in fall of ’06 of $780K).

Schedule has a reasonable float, even for August. Actual delivery of final half-cylinder in mid-December ’07 or even-mid January ‘08 would allow us to be ready to install when detector is opened from January ’08 until April ’08.

Summary – Issues and Request

- **We still have some issues**
  - **Bump bonding yield (contingency analysis contains $ to deal with this)**
  - **Quality assurance, especially with vendors (good interaction with IZM and RTI to resolve problems)**
  - **Yield, all the way through to full working panels**
  - **Integration and installation at CERN (contingency analysis includes $ to deal with unexpected costs)**

The project is moving ahead. If baselined at the proposed total cost of $12M (BAC) with an expected $2.2M cost to complete, and an estimated contingency of $470K($780K), we will deliver the Forward Pixel Detector at its planned scope, on schedule, and within budget.

Back-up Slides

FPIX Collaborators/Participants
June 2006

U of Colorado: **M. Bunce, J. Cumalat, M. DiNardo**, E. Erdos, **K. Stenson, S. Wagner**

Cornell U: **J. Alexander**, **S. Das, K. Ecklund**, J. Hunt, **H. Li, A. Ryd, J.Thom**, **J. Vaughan**

UC Davis: **J. Conway, R. Lander, D. Pellett**, M. Searle, H. Powell, **C. Veelken**

FNAL: **M. Atac,** B. Baldin, **J. Butler**, G. Cardoso de Cardoso, G. Derylo, I. Fang, B. Freeman, C. Gingu, **A. Hahn**, J. Howell, **S. Kwan**, S. Los, **P. Tan**, M. Turqueti, **U. Joshi, L. Uplegger, J.C.Yun**

U of Iowa: **C. Newsom, L. Perera**

JHU: B. Barnett, C.Y. Chien, A. Gritsan, P. Maksimovic, **M. Mathis, M. Swartz**, **Nhan Tran**

Kansas S.: **T. Bolton, Y. Maravin**, **D. Bandurin, D. Onoprienko, Z. Wan**, **K. Ketino**, R. Taylor, D. Huddleston

Milano: P. D'Angelo, **S. Erba, S. Magni, S. Malvezzi, D. Menasce, L. Moroni, D. Pedrini, M. Rovere, S. Sala**

Mississippi: **L. Cremaldi, D. Sanders**, M. Reep

U of Nebraska: **K. Bloom, D. Claes, A. Dominguez, M. Eads, S. Malik**

Northwestern: **B. Gobbi, M. Kubantsev**, E. Spencer, R.N.Tilden

Puerto RIco: **A. Lopez, H. Mendez**

Purdue: **A. Apresyan,** K. Arndt, **D. Bortoletto, G. Bolla, A. Garfinkel**, D. Graves, **M. Jones**, **P. Merkel, D. Miller, I. Shipsey, S. Son**, **B. Xin**

Purdue/Calumet: **N. Parashar, V. Cuplov**

Rutgers U: E. Bartz, J. Doroshenko, **A. Macpherson, S. Schnetzer, R. Stone**, Y. Streltsov

SUNY/ Buffalo: **I. Iashvilli, A. Kharchilava, A. Kumar, M. Strang**

Vanderbilt U: **W. Johns, E. Vaandering**

U of Virginia: **S. Conetti, B. Cox, R. Hirosky, M. Arenton, A. Ledovskoy, A. Kreymahdi**, H. Powell, **D. Phillips, M. Ronquest, D. Smith**, **D. Andelin, M. Balazs, R. Imlay**, **R. Yohay**

18 institutions; 77 physicists, 25 engineers and technicians; 14 grad students; and one remaining applicant: Tennessee

Graduate student Ph.D. Physicist Engineering/technical

Responsibilities - I

Colorado	Tracking, mechanical, tracking, Run ’07/CERN setup
Cornell	Online System, Calibration
U of California, Davis	Integration/installation, slow controls, Run ’07/CERN setup
U of Iowa	Slow controls, test beam
FNAL	VHDIs, Panel Production, mechanical, chip testing, electronics boards, half-cylinder assembly, database
Johns Hopkins	Sensor testing, alignment, tracking
Kansas State	VHDI testing, simulation
Milano	Test beam, alignment, test stand software, Run’07
Mississippi	Slow controls

Responsibilities - II

U of Nebraska	Testing plan development, DQM, production testing
Northwestern	Mechanical design, test stand software, half-cylinder assembly
Puerto Rico	Testing, simulation
Purdue	Sensor testing, Plaquette, construction, bump bonding
Purdue/Calumet	Simulation, burn-in testing
Rutgers	TBM, FEC, electronics coord.
Suny/Buffalo	Database
Vanderbilt	Database, FED software
U of Virginia	Burn-in box construction