



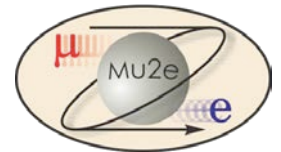
U.S. DEPARTMENT OF
ENERGY Office of
Science

Mu2e CD-2 475.09.04 Data Processing

Ryan A. Rivera

L3 Manager

7/8/2014

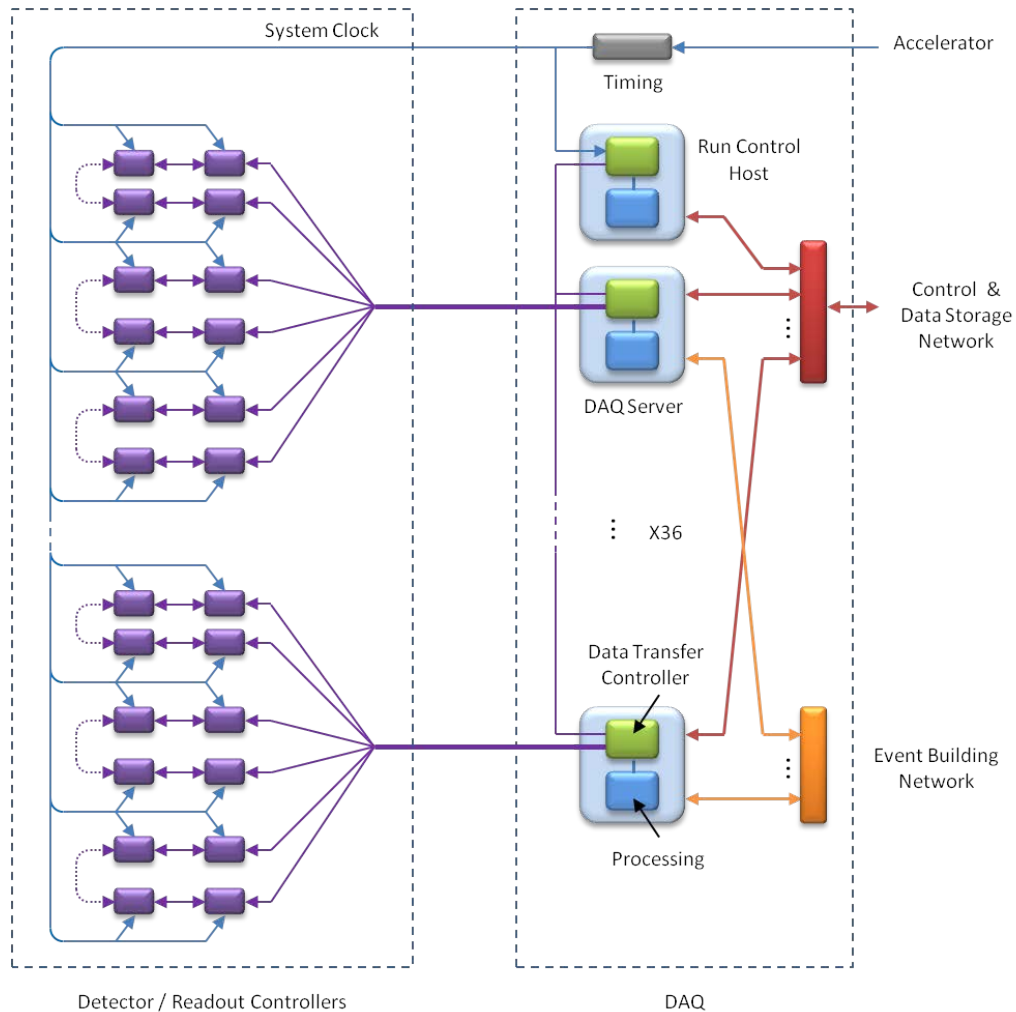


Requirements

- DAQ Servers
 - For dataflow management and online filter processing
- Run Control Host
- Detector Control System (DCS) Host
- Data Logger Host and connection to offline storage
- The data processing software infrastructure (based on *art*)
- Filter software development and optimization
 - Reduce data rate by a factor >100
 - Offline data storage $< 7\text{PB/year}$

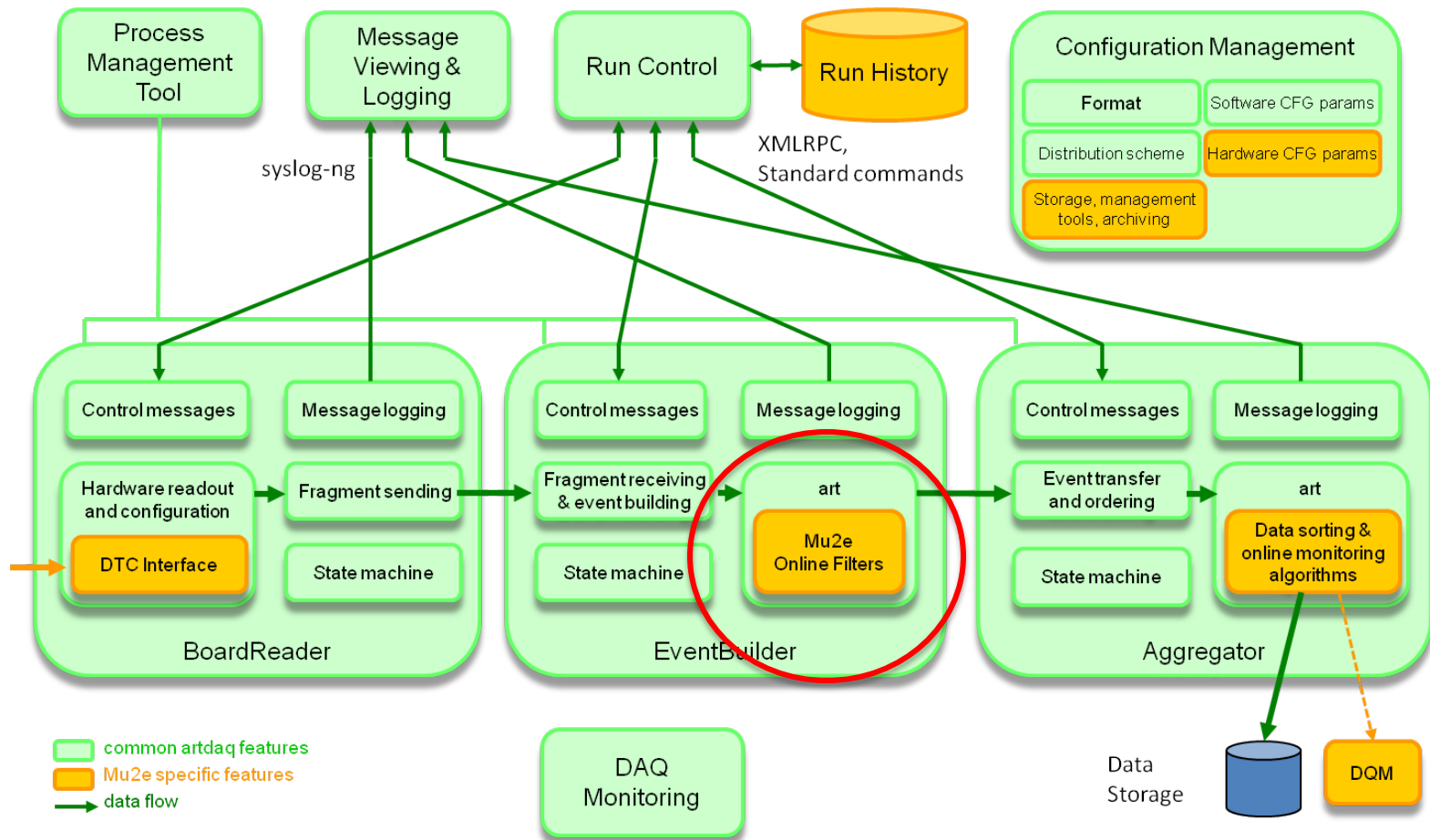
Design

Data Processing System (DP) Hardware



Design Cont.

Data Processing System (DP) Software



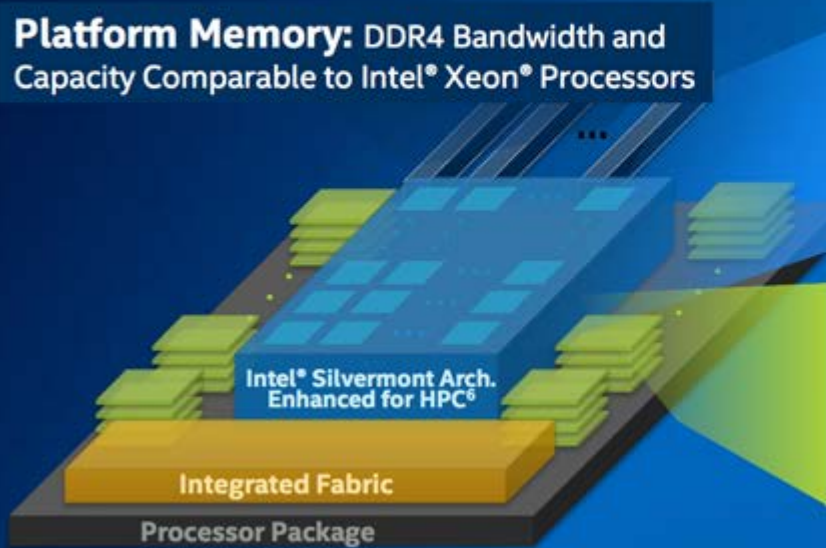
Design Cont.

Tracking Filter Optimization

	XEON E5-2687v2	XEON PHI 5510P
Stereo Hits		
0) reference code (gcc compiler)	83.6 msec	-
1) algorithmic improvements (gcc compiler)	4.3 msec	-
2) Intel compiler, loop vectorization	1.4 msec	4.8 msec
Background Hits		
0) reference code (gcc compiler)	9.0 msec	-
1) Intel compiler	5.1 msec	123.0 msec
2) refactoring	3.4 msec	38.1 msec
3) double → single precision	2.1 msec	23.9 msec
Overhead		
0) reference code (gcc compiler)	0.9 msec	-
1) Intel compiler (estimated)	0.3 msec	2.0 msec
total processing time	3.8 msec	30.7 msec
events/sec (single core)	260	32
number of cores (36 servers)	720	4,320
events/sec (36 servers)	187,000	138,000

Design Cont.

- Future processing power example to be released 2015
 - 3X performance over 5110P



The diagram shows a 3D perspective of the Intel Knights Landing processor. It features a central blue chip labeled 'Intel® Silvermont Arch. Enhanced for HPC⁶' mounted on a yellow 'Integrated Fabric' which is part of a 'Processor Package'. The chip is connected to multiple layers of green memory modules. The background is a dark blue gradient with white and yellow text boxes providing technical specifications.

3+ TFLOPS¹
In One Package
Parallel Performance & Density

New for Knights Landing
(Next Generation Intel® Xeon Phi™ Products)

★ **2nd half '15**
1st commercial systems

Platform Memory: DDR4 Bandwidth and Capacity Comparable to Intel® Xeon® Processors

Compute: Intel® Silvermont Arch. (Intel® Atom™)²

- Low-Power Cores with HPC Enhancements³
- **3X** Single Thread Performance⁴ vs Prior Gen.
- Intel Xeon Processor Binary Compatible⁵

On-Package Memory: High Performance

- up to **16GB** at launch
- **1/3X** the Space⁶
- **5X** Bandwidth vs DDR4⁷
- **5X** Power Efficiency⁶

Jointly Developed with Micron Technology

LEARN MORE: Knights Landing Webcast (Tuesday June 24th):
<https://www.brighttalk.com/webcast/10773/116329>

Changes since CD-1

- CRV output rate change is increase of 7x data rate for online data processing filter.

Performance

- Each DAQ server is specified to add approximately 1 GByte/sec of bandwidth and 1 TFLOPs of online processing capability.
- Online Tracking Filter is close to making production requirement of 192,000 events/sec.
 - Expect 2x speedup in technology and additional room for optimization.

Remaining work before CD-3

- Pilot System
 - 6 server test system with event building network
 - Initial Mu2e specific version of the *art* software
 - Optimized version of the tracking filter software
 - Benchmarks of the tracking filter in a high rate environment

Organizational Breakdown

- L2 Manager – M. Bowden
- L3 Manager – R. Rivera
- Engineers/Application Developers – R. Rechenmacher, K. Biery, R. Kwarciany, G. Deuerling, M. Wang

Quality Assurance

- Data Processing plans for 16 month period of optimization and debug at end of Production phase.
- Production phase completion date is 7/27/2018.

Risks

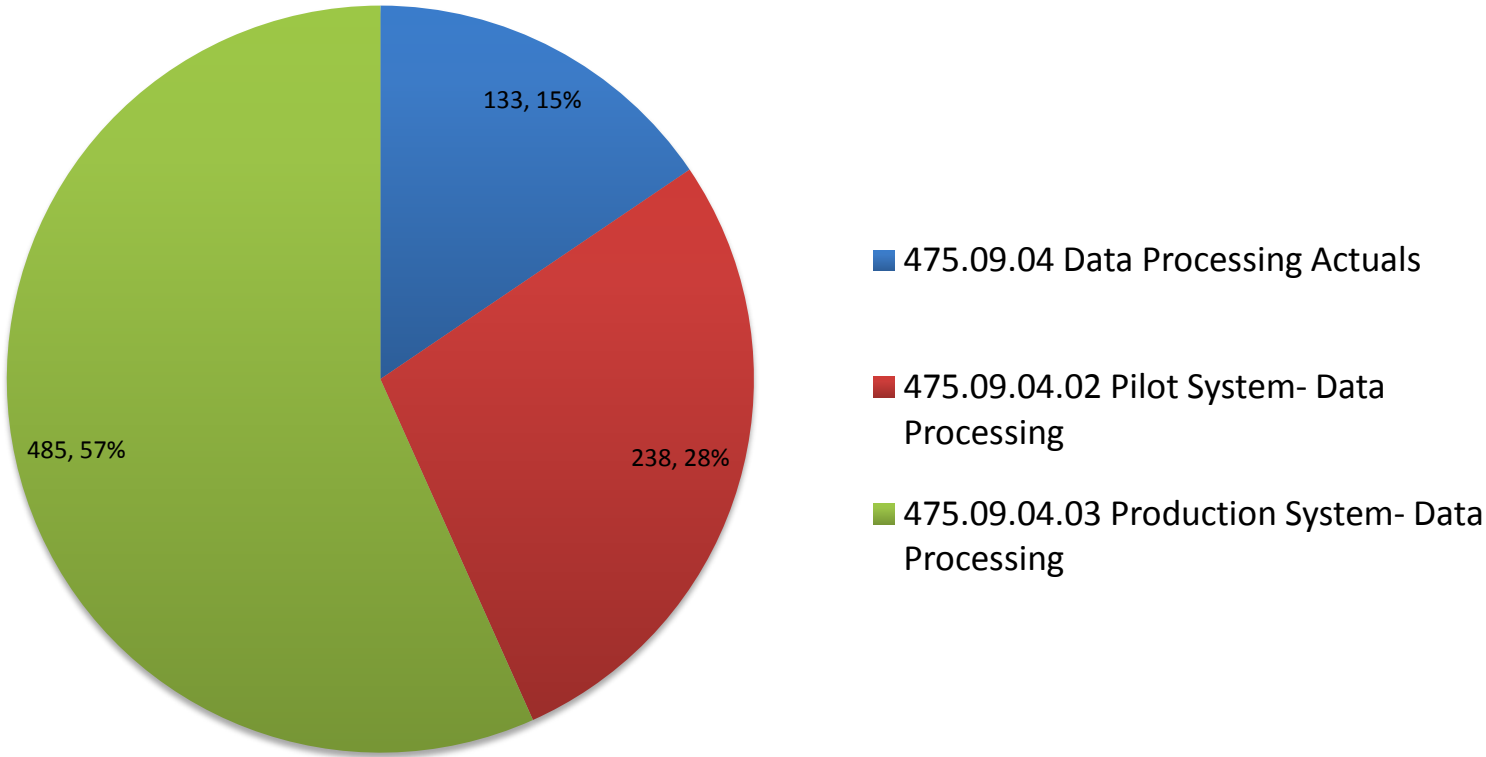
- Insufficient manpower for DAQ software.
 - Risk Cause: Expecting a substantial fraction of effort to be off project, written by physicists. Difficult to estimate software effort for particular software tasks.
 - Risk Effect: Increase in software development time/costs.
- Insufficient DAQ online processing.
 - Risk Cause: Lack of detailed performance benchmarks. Overestimate of future processor performance/cost improvements.
 - Risk Effect: Lower than expected rejection rate. Increased cost of offline storage/processing. Reduced data collection efficiency.

Risks Cont.

- Higher than expected data rates to the DAQ.
 - Risk Cause: Underestimate of particle flux and detector activity
 - Risk Effect: Reduced data collection efficiency

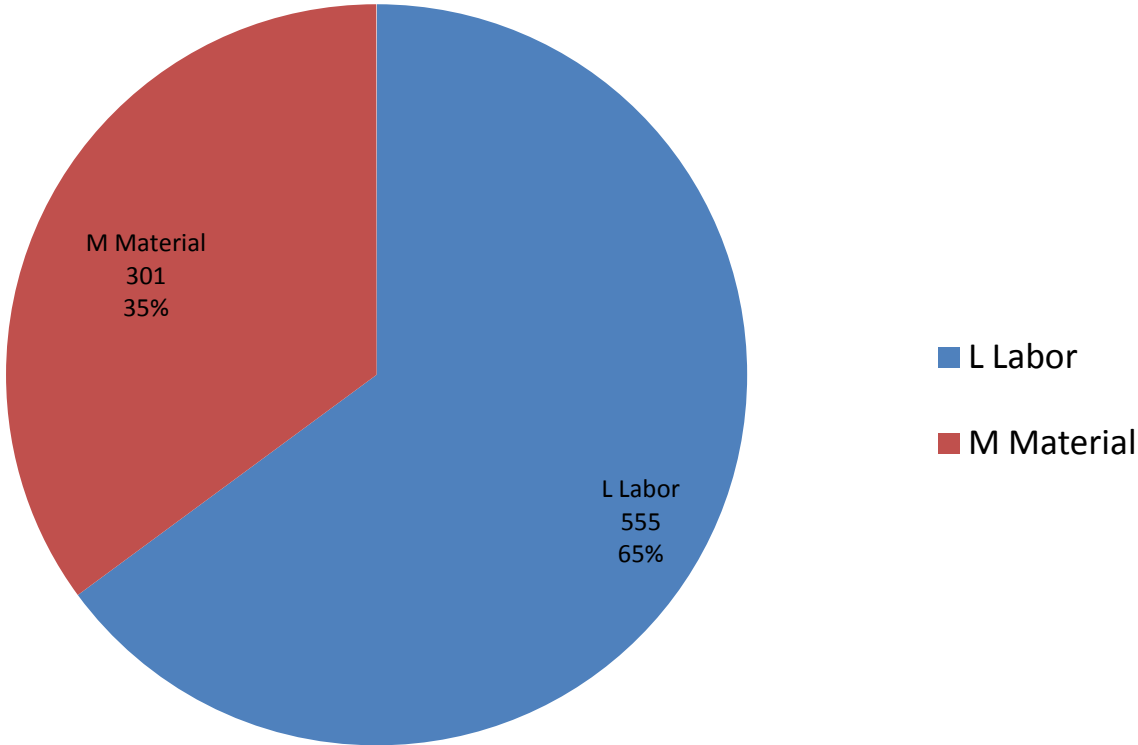
Cost Distribution by L4

Base Cost by L4 (AY \$k)



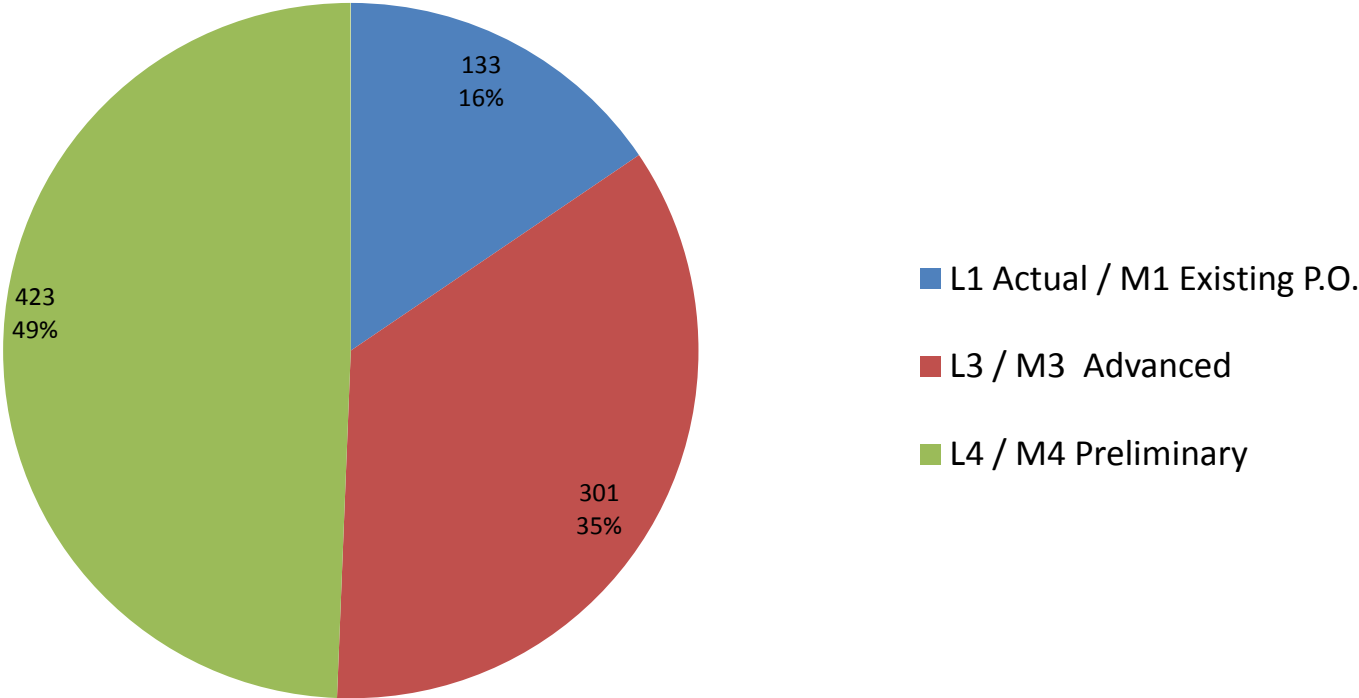
Cost Distribution by Resource Type

Base Cost (AY \$k)



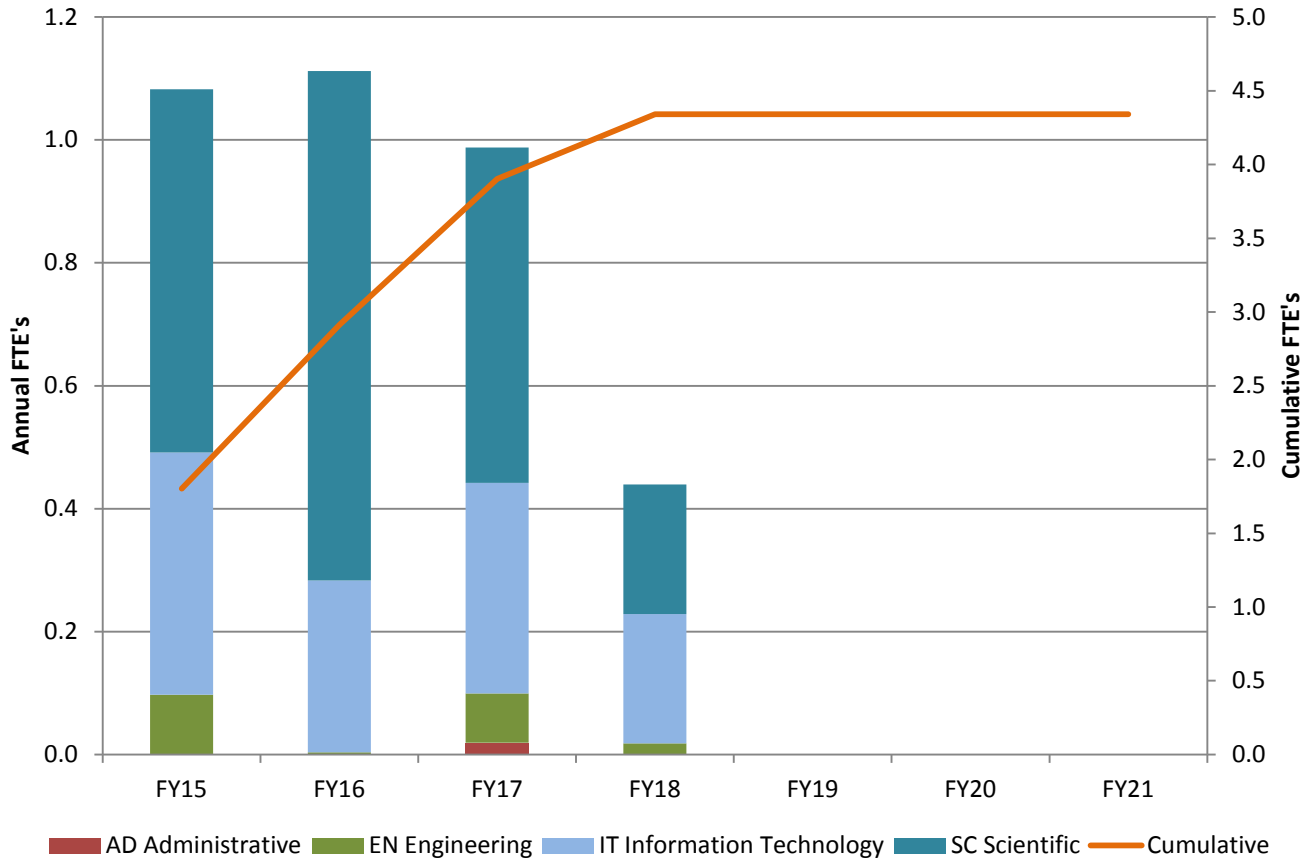
Quality of Estimate

Base Cost by Estimate Type (AY\$k)



Labor Resources

FTEs by Discipline



Cost Table

WBS 9.4 Data Processing

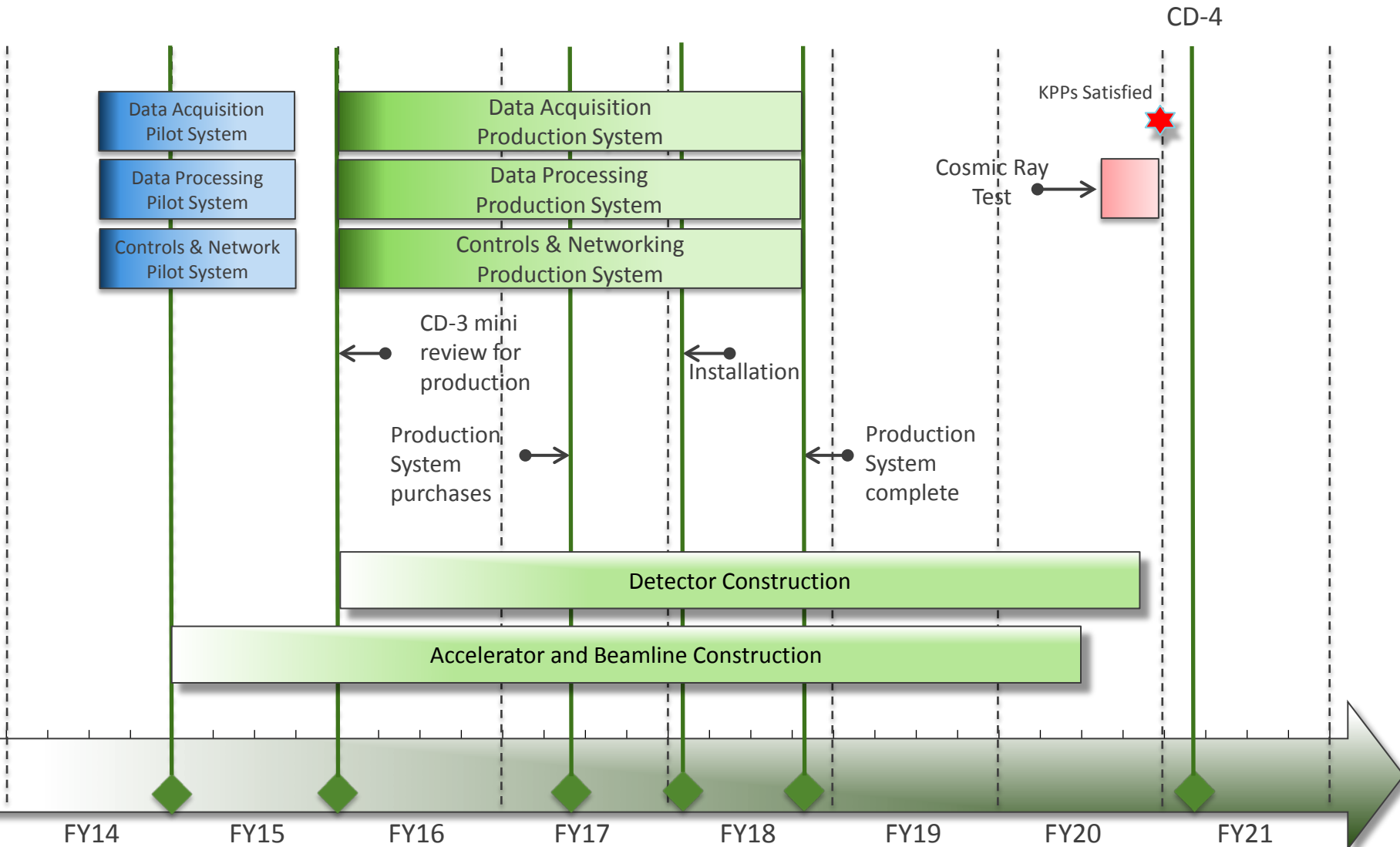
Costs are fully burdened in AY \$k

	M&S	Labor	BAC	Estimate Uncertainty	% contingency on ETC	Total
475.09 Trigger & DAQ						
475.09.04 Data Processing						
475.09.04 Data Processing Actuals		133	133			133
475.09.04.02 Pilot System- Data Processing	41	197	238	77	32%	315
475.09.04.03 Production System- Data Processing	260	225	485	131	27%	616
Grand Total	301	555	856	208	29%	1,064

Major Milestones

- Prototype System Complete (4/30/2014)
- Pilot System Complete (6/11/2015)
- Production System Complete (7/27/2018)

Schedule



Summary

- Data Processing is on pace and in position to proceed with Pilot System.