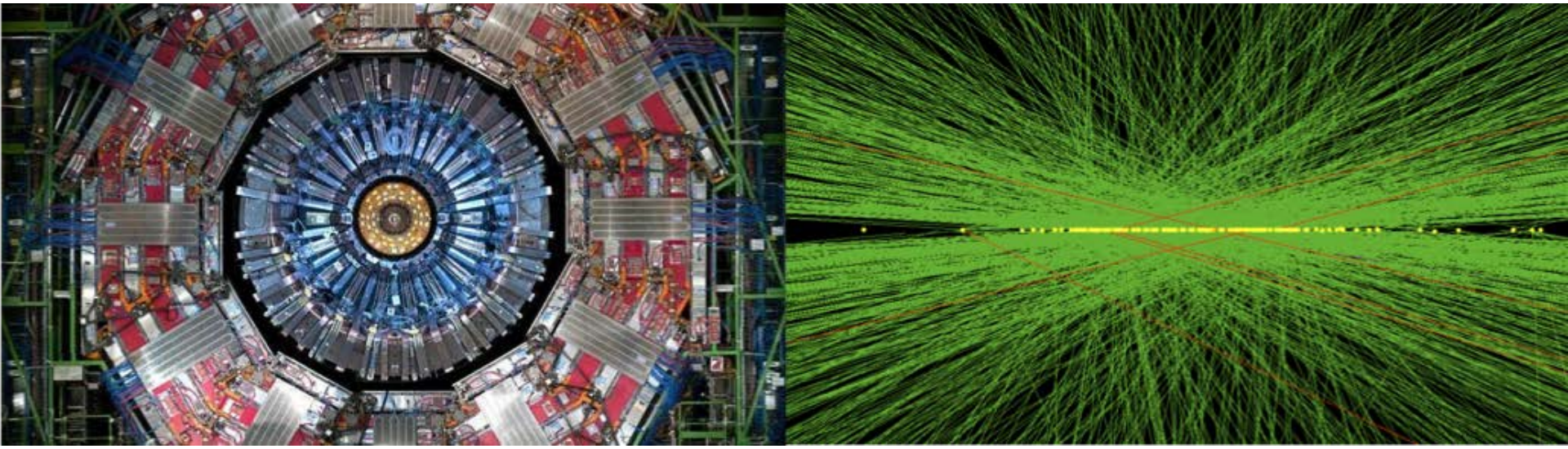
HL-LHC CMS Upgrade QA Plan

T.J. Sarlina, HL-LHC CMS QA Coordinator

ESH and QA Review

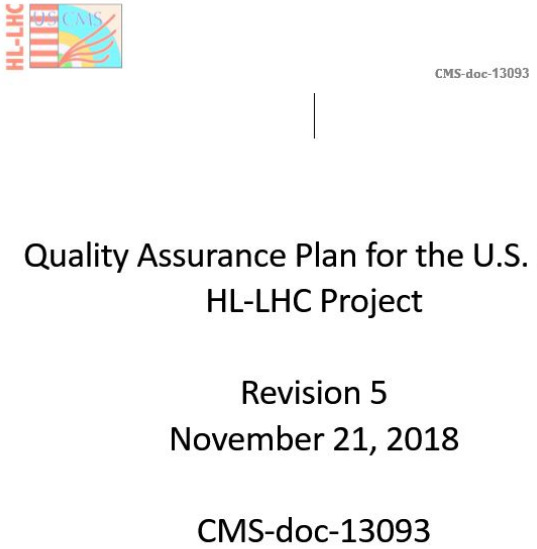
November 29, 2018



Biographical Sketch

- CMS Upgrade QA Coordinator (T.J. Sarlina)
  - Assistant Radiation Safety Officer for Meson Department (1979-1982)
  - Fermilab Senior Safety Officer for Research Division and Particle Physics Division (1982-2002)
  - Project Scheduler (2002-2008)
    - CDF Upgrade Project, DO Upgrade Project, Minerva, Dark Energy Camera.
  - Project Manager at Fuel Tech, Inc. (2008-2010)
    - Air Pollution Control Projects (power plants and refineries) in Hong Kong, Guangzhou, Liaoning Province. Austin, TX and Seattle, WA.
  - Associate Project Manager for ESH and QA for NO*v*A (2010-2014)
    - Constructed and commissioned Near Detector at Fermilab and Far Detector in Ash River, MN.
  - Fermilab Quality Assurance Manager (2014-2017)
    - Transitioned the Fermilab QA Program from consultant led to internally owned.
  - Fermilab Quality Assurance Specialist (2017-present)
    - Supporting the Fermilab QA Program under Jemila Adetunji, IERC QA Coordinator, CMS US HL-LHC QA Coordinator

Quality Assurance Plan


CMS-doc-13093

Quality Assurance Plan for the U.S. CMS
HL-LHC Project

Revision 5
November 21, 2018

CMS-doc-13093

- Key Elements
  - Defines Quality Assurance expectations from international CMS through Fermilab to participating institutions in the U.S.
  - Assigns roles and responsibilities for QA oversight
  - Outlines the work process controls and QA validation to ensure that CMS achieves the stated science requirements

CERN DocDB # 13093

CMS Collaboration Quality Assurance

- Overall responsibility for CMS QA is held by CERN and the international CMS collaboration
- CERN has a formal review and approval process for all LHC experiments
- U.S. QA processes are derived from international CMS QA processes
- If an inconsistency arises, the international process will take precedence
- The CMS Technical Coordinator – Austin Ball, appointed by CERN, holds overall responsibility for all CMS activities

CMS Project Reviews

- Standard technical or engineering design reviews, procurement readiness reviews, etc. provide QA during R&D and Preproduction activities
- Standard acceptance reviews, such as production readiness reviews or installation readiness reviews provide QA during production and installation activities
- Ad Hoc reviews may be called on an as-needed basis by the U.S. Project

QA Project Reviews

- Reviews are scheduled at four stages of the project:
  - Stage 1 – Initial Design
  - Stage 2 – Baseline Design
  - Stage 3 – Final Design/Start of Construction
  - Stage 4 – Installation and Commissioning
- Each review stage includes a QA component
- You heard more detail about these in presentations from Vivian and Chris

U.S. CMS Quality Assurance

- QA is an integral part of the design, fabrication, and construction of the HL-LHC U.S. CMS Upgrade Project
- All components and subproject deliverables must meet approved science and engineering technical requirements listed for each WBS Level 2 subproject
- The QA Plan applies to all U.S. CMS Project activities funded and undertaken by the Department of Energy (DOE) and the National Science Foundation (NSF)
- QAP is a controlled document and is approved & signed by the PM (DOE), Deputy PM (NSF), Fermilab Chief Project Officer, and CMS QA Coordinator
- Each participating institution is responsible for the day-to-day QA practices relevant to their work

QAP Overview

- Describes the QA requirements and processes for international CMS and CERN QA oversight as well as U.S. CMS QA oversight
- General in nature due to differences in the type of deliverables for each subproject as well as the methods of interaction between subprojects
- Subproject details are described in the QA appendices and Carol will go into more depth in her presentation
- QA activities are tied to technical requirements (Chris and Carol presentations)

QAP Overview

- Section 4 highlights the international CMS review & approval
  - Determination of technical requirements
  - Design validation
  - Approval of QA activities
  - Acceptance of components
  - QA Managers for subdetector projects are assigned by CMS (Chris Hill's talk)
- Section 5 has Roles and Responsibilities for CMS, CERN, and U.S. personnel
- Section 6 describes the U.S. QA efforts
  - Production and testing is the responsibility of U.S. managers for their scope of work
  - QA ensures they are meeting CMS requirements

Roles and Responsibilities

- Project Manager has ultimate QA responsibility for U.S. scope
- Project Scientist works with Subproject Leads and QA Coordinator to ensure technical requirements are met
- Subproject Leads (WBS L2, L3, L4) are responsible for their scope of work
- QA Coordinator ensures QA planning and execution follows QAP, provides planning support & review of participating institution QA procedures, and participates in surveillance reviews of work execution

QA at Participating Institutions

- QA plans and procedures that cover CMS work are a joint effort by Level 2 Manager, Project Scientist, QA Coordinator, and site representatives
- Review and approval of QA/QC processes at institutions will fall to the appropriate Level 2 Manager and the QA Coordinator, including site visits where necessary
- There will be a designated QA contact at each site

Site Field Audit Checklist

US-HL-CMS Quality Assurance Audit Field Checklist

WBS X.X.X *Date:*

Contacts: *Location:*

1.	Material/Component Receipt	Yes	No	N/A
	Have acceptance criteria been defined by the organization?			
	Are the criteria written down, approved, and entered into a database?			
	Did the criteria change over time with documentation entered into a database?			
	If changes have occurred, have they been approved by appropriate authority?			
	Is data transmitted from last organization in a timely way and is it useful?			
	Do written procedures exist and are they followed?			
	Are personnel properly trained to conduct acceptance checks?			
	Are the results being documented in a consistent manner?			
	Are test results entered into a database?			
	Is all measuring and test equipment properly calibrated?			
	Are components and samples stored properly in secure and/or segregated locations to prevent damage or loss?			
2.	**Quarantine of Deficient or Non-Conforming Product**	**Yes**	**No**	**N/A**
	Are storage areas properly identified?			
	Is product labeling clearly visible and consistent?			
	Have non-conformance procedures been written and approved?			

Site Field Audit Checklist

3.	**Personnel Training**	**Yes**	**No**	**N/A**
	Do current, written procedures exist for each process?			
	Do posted instructions agree with authorized, written procedures?			
	Is there a process for informing or re-training workers when procedures change?			
	Are procedural changes reviewed for impact on the final product?			
4.	**Acceptance Criteria For Finished Product**	**Yes**	**No**	**N/A**
	Have acceptance criteria been defined by the organization?			
	Are the criteria written down, approved, and entered into a database?			
	Did the criteria change over time?			
	Have updated acceptance specs been approved and documented in a database?			
5.	**Records, Logs, and Databases**	**Yes**	**No**	**N/A**
	Have standard forms/spreadsheets been created to record data?			
	Is information entered in a timely and consistent manner?			
	Has the information been entered into a database?			
	Are paper copies stored in an organized and secure manner?			
	Are local databases backed up to prevent loss of data in the event of a failure?			
	Is data available to personnel outside the originating institution?			

Site Field Audit Checklist

6.	**Information Flow Between Facilities**	**Yes**	**No**	**N/A**
	Has data that needs to be transmitted to the next production phase been identified?			
	Is information transmitted in a timely manner?			
	Is the transmitted information useful to the next phase?			
	Is transmitted information handled and stored appropriately?			
7.	**Trend Analysis**	**Yes**	**No**	**N/A**
	Are methods employed to evaluate vendor performance over time?			
	Are methods employed to evaluate facility performance over time?			
	Have action levels or points been identified where corrective actions are required?			
	Are evaluations geared to identify gradual changes as well as sharp deviations?			
8.	**Preventing Problem Recurrence**	**Yes**	**No**	**N/A**
	Does a program exist to prevent recurrence of identified problems?			
	Are workers alerted to or informed about identified problems?			

Site Field Audit Report

US HL CMS QA Audit Report for WBS X.X.X – (Insert WBS Name)
Level 2 Manager – (Insert Name
(Date)

BACKGROUND:

The U.S. HL CMS Project Office conducts internal QA audits on operations related to construction of the experiment to ensure acceptance criteria have been defined and documentation is up to date. This WBS Section X.X.X audit, conducted by (Insert Names), examined operations at (Insert Facility) in (Insert Location) and (Any other locations if necessary).

FINDINGS AND OBSERVATIONS:

Section I - Material/Component Receipt, Testing, and Shipment

1. Detail findings from field checklist and tie to specific Recommendations at the end of this document. (See Recommendation #X)

2. List Best Practices as appropriate.

Section II - Quarantine of Deficient or Non-Conforming Product

1. Detail findings from field checklist and tie to specific Recommendations at the end of this document. (See Recommendation #X)

2. List Best Practices as appropriate.

Section III - Personnel Training/Operational Procedures

1. Detail findings from field checklist and tie to specific Recommendations at the end of this document. (See Recommendation #X)

2. List Best Practices as appropriate.

QA Activity Spreadsheets

L2 WBS	Subsystem title	L2 Lead
402.02	Outer Tracker	S Nahn, P Merkel

WBS	WBS Title	L2, L3, L4 Lead	Sub-Project/Sub-component	Institution/ Work Area	QA Coordinator/ Contact	Quality Control or Assurance Activity/
402.02.06	Mechanics	S. Gruenendahl, R.Lipton	Thermal and Mechanical FEA modeling and comparison	FNAL	S. Gruenendahl	Measurement

WBS	Validation / Verification Activities	Inspection / Acceptance Test Activities	Requirements/ Specifications	Requirement ID	Requirement Title
402.02.06	Design validation through mechanical/thermal modelling and comparison with prototypes		CMS DocDb Ref # 13384, 13397	OT-eng-018, OT-eng-032, OT-eng-033, OT-eng-041, OT-eng-042	Flat Barrel Cooling Performance, P2/2S Mechanical Structure and Module Cooling

WBS	Measurement/ Method	Associated Hardware/ Software	Standard / Procedure / Process Doc	Calibration Planning	Record (Data, Calibration, etc.)	Training and Qualifications
402.02.06	Planks and Rings will be mechanically and thermally modeled and results compared with testing on prototypes with CO2 cooling, testing for heat conductance and rigidity	Cold box, Thermal sensors and heating elements, FEA modelling software		FEAs and thermal mockups will be cross-validated	Prototype testing will be analysed and presented for peer scrutiny	A certain amount of previous experience in modelling and prototyping is necessary

Appendix A Overview

- Each WBS documents an overview of scope
  - Participating institutions, deliverables, and activities for each
- Organization and interfaces
  - DOE/NSF coordination
  - International CMS coordination
  - Coordination with a different WBS
- Design validation methods
- Production verification
- Document/record storage

Trigger/DAQ - Scope

1. Trigger/DAQ Scope

The CMS Trigger Systems Upgrade Project will analyze, accept, and reduce the data stream from the backend electronics of most of the CMS subdetectors for the most scientifically valuable events to 7.5 kHz. It provides the digital electronics, associated infrastructure, firmware, and software to replace the existing CMS Layer 1 (L1) Trigger and DAQ to enable higher data rates and to take advantage of technical advances. The U.S. Trigger/DAQ subproject consists of both NSF and DOE scope under combined, single management but with subcomponent deliverables held separately at WBS Level 3.

The DOE deliverables include design, production, and testing of:

- **electronics, firmware, and software for the L1 Barrel Calorimeter Trigger system (402.6.3)**
- **electronics, firmware, and software for the L1 Layer-1 Correlator Trigger system (402.6.5)**, and
- **hardware and software for the DAQ Storage Manager and Transfer System (402.6.6).**

The NSF effort entails design, production, and testing of:

- **electronics, firmware, and software for the L1 Muon Trigger system (402.6.4)**, and
- **electronics, firmware, and software for the L1 Track Trigger system (402.6.7).**

Trigger/DAQ – Organization & Interfaces

DOE Responsibility		
Wisconsin	Calorimeter Trigger	HW, FW, SW engineering, algo development, procurement
Colorado	Correlator Trigger	FW, SW engineering, algorithm development
Fermilab		FW engineering, algorithm development
Florida		HW, FW, SW engineering, algorithm development
MIT		Algorithm development
Northwestern		Algorithm development
Texas A&M		FW, SW engineering, algorithm development
UIC		Algorithm development
Wisconsin		HW, FW, SW engineering, algo development, procurement
Fermilab	DAQ	Storage Manager specification, procurement, operations
MIT/Rice/UCSD		Storage Manager specification, operations

Trigger/DAQ – Design Validation

A.4.3.1 Design Validation:

Designs for electronics and firmware will be verified by engineering analysis and demonstrations with prototypes and simulated data. Software and algorithms will be quality tested using measurement and analysis.

Trigger/DAQ has passed a set of initial design reviews:

- L1 Trigger Interim Technical Design Report (TDR) published and accepted by LHCC early 2018 (CMS-TDR-017)
- NSF preliminary design review passed (muon trigger, track trigger) Dec. 2017.
- DOE Critical Design Review 1 recommendation passed (calorimeter trigger, correlator trigger, DAQ storage) June 2018

Planned future CMS reviews include a CMS L1 Trigger TDR in 2020, a DAQ/HLT TDR in 2021, and a CMS Electronics Systems Review (ESR) stage-gate for L1 trigger construction in 2021. In addition, internal project design progress reviews are planned as the various component designs mature to provide design validation and verifications. Funding agency reviews of the project are scheduled for end of 2019 (FDR/CD2)

Trigger/DAQ - Production Verification

A4.3.2 Production Verification:

Trigger/DAQ prequalifies vendors through capability studies and or prototype and preproduction runs. While procurements will proceed through the University of Wisconsin, Cornell University, and Fermilab, all procurement procedures will follow the *Fermilab Procurement Manual*, with QA/QC plans and responsibilities determined and agreed to in advance of award. Experienced vendors are regularly qualified through R&D, pre-production, and production orders for board manufacture, parts ordering and board assembly. The University of Wisconsin and Cornell University have long standing experience with vendors of required electronics, and Fermilab has long standing experience with required DAQ storage manager vendors.

Summary

- Quality Assurance resources have been assigned with defined roles and responsibilities
- We have established the hierarchy of Quality Assurance controls to participating institutions
- We have met the requirement of 413.3B to have a Quality Assurance Plan
- We have addressed the comments from the previous review
- We are ready for the Director's Review and the DOE CD-1 mini-Review in the coming year

Back-up Slides

CMS QA Oversight

- CERN LHCC/UCG
  - Responsible for approving plans for QA as part of Step 2 baseline design approval and at Step 3 for detailed implementation approval.
- CMS Upgrade Coordination Lead
  - Responsible for calling for and conducting the CMS internal reviews leading to Step 2 and working with the CMS Technical Coordinator for reviews leading to Step 3.
- CMS Subdetector Leads
  - Responsible for oversight and management of their integrated detector subsystems, which include efforts from all participating contributors.
- CMS Subdetector QA Manager
  - Responsible for coordinating QA processes across all participating institutions for that subdetector.
  - Responsible for defining or approving test procedures for each component or subassembly and the use of a common data-base and tracking tools to ensure selection/matching of components in the final assembly and to allow correlation between operational performance and the history of components in the construction process.

CMS QA Oversight

- CMS Technical Coordination and Electronics Coordination Leads
  - Responsible for providing technical oversight and coordination of all parts of the detector.
  - Keeping up-to-date drawings and ensuring overall inter-compatibility between CMS subcomponents and LHC infrastructure.
  - Participating in planning of QA activities and metrics
  - Calling for reviews of all subprojects during design, after final designs, before production, before installation, and before operations (EDR, PRR, IRR, ORR
  - Coordinating CMS subprojects points of contact to CMS Technical and Electronics Coordination
  - Maintaining technical documentation in the CMS EDMS document system, including specifications and QA procedures

US CMS Project Scientist

- Developing Technical Requirements using the Science Flow Downs, working with the L2 and L3 Managers
- Supporting planning and providing review of the Quality Tests and Inspections developed by the WBS Level 2, 3, & 4 Systems Engineers/Managers, as identified in the CMS reviewed and approved Technical Requirements
- With the QA Coordinator, coordinating the Quality Assurance planning of WBS Level 2, 3, and 4 Systems Engineers/Managers to ensure that the work at all participating institutions meets the Science and Technical Requirements

US CMS QA Coordinator

- Develops the U.S. CMS QA Plan. Reviews the QAP and updates the Plan as necessary or at least once a year;
- With the Project Scientist, coordinates the QA planning of WBS Level 2, 3, and 4 Systems Engineers/Managers to ensure that the work meets science objectives and Technical Requirements;
- Provides planning support, review, and approval of the participating institutions' QA plans/procedures developed by WBS Level 2, 3, and 4 Systems Engineers/Managers, including site visits as necessary;
- Participates in surveillance reviews of work execution to ensure that the QA plans/procedures are followed;
- Provides training and coaching in QA practice for Project Office and WBS Level managers, as needed;
- Tracks the U.S. Quality Assurance efforts, ensures proper documentation, and facilitates integration with overall CMS.

US CMS Subproject L2 Managers

- Working with CMS subproject leads, the Upgrade Coordination, Technical Coordination, and Electronics Coordination Leads to provide integrated QA for the U.S. scope
- Developing their Level 2 System's Quality Assurance programs per the graded approach in this Plan, working with the U.S. QA Coordinator and participating U.S. institutions as appropriate
- Overseeing Level 3 and 4 QA planning and execution to ensure that it follows their QA plans/procedures and meets science objectives and Technical Requirements
- With the QA Coordinator, providing review and approval of the Quality Assurance planning and execution of work at all participating institutions, including site visits, to ensure that it meets science objectives and Technical Requirements
- Promptly notifying Project Managers, Project Scientist and Project Engineer of proposed or potential changes to Technical Requirements Acceptance Methods

US CMS Subproject L3, L4 Managers

- Developing their System's Quality Assurance programs per the graded approach in this Plan, working with the Level 2 Managers and the participating institutions and QA Coordinator as appropriate
- Overseeing execution of work at all participating institutions to ensure that it follows the QA plans/procedures and meets science objectives and Technical Requirements
- Promptly notifying Level 2 Managers of proposed or potential changes to Technical Requirements Acceptance Methods