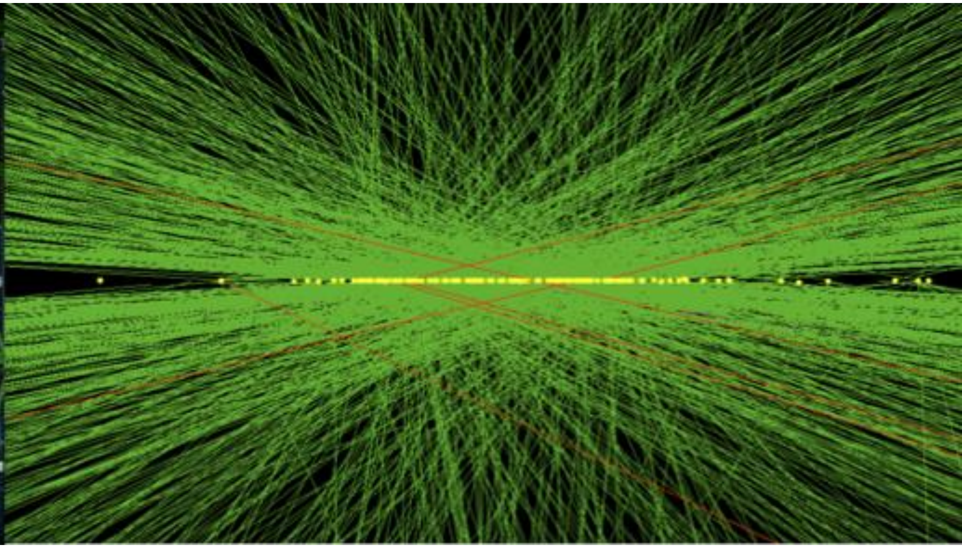
B03: HL-LHC CMS Upgrade QA/QC Plan

Carol Wilkinson, Associate Project Manager

CD1 Review

October 23rd, 2019



Outline

- Biographical Sketches
- U.S. CMS QA/QC Program
  - QA/QC Components
  - QA Plan Key Elements
  - Section 4: CMS/CERN QA Processes
  - Section 5: Roles and Responsibilities
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  - QA Activity spreadsheets: Technical flowdown and summary of QA/QC
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- Response to Previous Reviews
  - (Includes 2018 IPR Recommendations and 2019 DR Recommendations)
  - Section 7: Participating Institutions
- Summary

Biographical Sketches

- T.J. Sarlina: CMS Upgrade QA Coordinator
  - Fermilab Quality Assurance Manager and Specialist; IERC and CMS US HL-LHC QA Coordinator (2014-present)
  - Associate Project Manager for ESH and QA for NOvA (2010-2014)
  - Project Manager at Fuel Tech, Inc. for Air Pollution Control Projects (2008-2010)
  - Fermilab Project Scheduler CDF Upgrade Project, DO Upgrade Project, Minerva, Dark Energy Camera (2002-2008)
  - Assistant Radiation Safety Officer for Meson Department (1979-1982)
  - Fermilab Senior Safety Officer for Research Division and Particle Physics Division (1982-2002)

- Carol Wilkinson – CMS Upgrade Associate Project Manager
  - Consultant with 25+ years management experience with DOE and NSF large facilities (2016-present)
  - Visiting Facility Advisor with NSF Large Facilities Office (2013-2016)
  - Advanced LIGO Project Manager (2003 -2013)
  - Los Alamos Project Manager - Nuclear Weapons Hydrotesting Program (2002 – 2003)
  - Los Alamos Project Manager and Group Leader – DAHRT Accelerator Operations and Facility Construction (1999-2002); Deputy (1998-1999)
  - Los Alamos LAMPF Team Leader - Beam Line and Accelerator Physics (1989-1998)

U.S. CMS QA/QC Program

Quality Assurance for U.S. CMS deliverables ensures that the CMS experiment achieves its science requirements and goals.

(listed in the document
Science Requirements for U.S. CMS HL-LHC, CMS-doc-13337)

Major components of the U.S. CMS QA Program are:

- Quality Assurance Plan (CMS-doc-13093)
- Subproject (L2) Quality Assurance Plans in QAP Appendix
- Subproject (L2) QA/QC Activities Spreadsheets with ties to requirements and detailed procedures
- Resource-loaded activities in P6 schedule
- Experienced, dedicated, and pro-active technical leads
- Assigned FNAL QA Coordinator for U.S. CMS effort
- Oversight by CERN, CMS, and U.S. CMS management

Quality Assurance Plan (QAP)

CMS-doc-13093

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

Revision 6.1
August 26, 2019

CMS-doc-13093

CMS-doc-13093

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

Appendix Revision 5
October 8, 2019

CMS-doc-13093

QAP Appendix contains detailed QA implementation for each L2 subproject

Key Elements

- Applies to both NSF and DOE funded activities
- Describes the QA requirements and processes for international CMS and CERN oversight as well as U.S. CMS oversight.
- Describes responsibilities for each U.S. participating institution for the day-to-day QA/QC practices relevant to its work.
- Controlled document approved & signed by U.S. CMS PM, Deputy PM, and QA Coordinator
- Appendix provides specific detail allowing for differences in sub-project deliverables and organization.

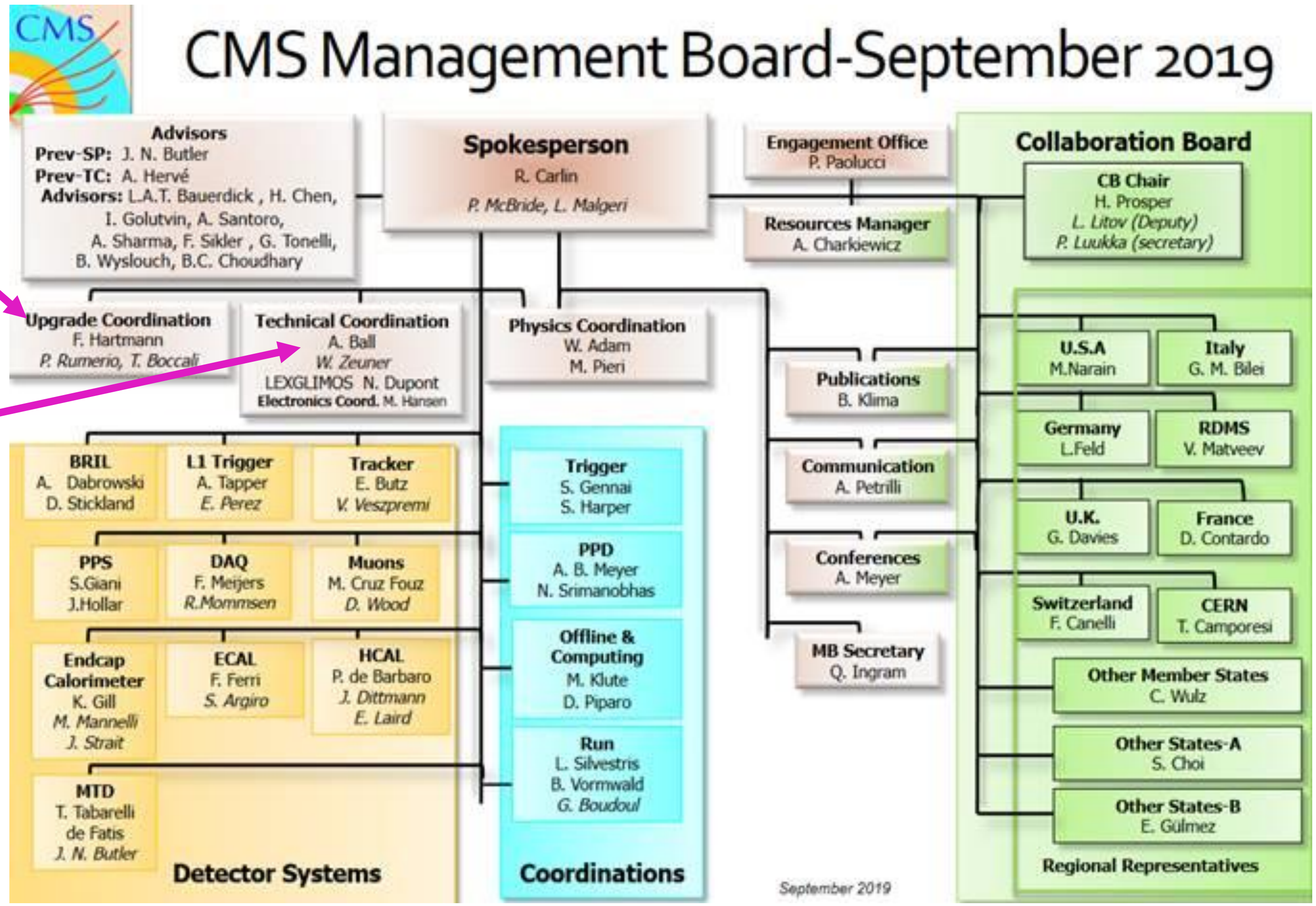
Under CERN/CMS Collaboration QA

- CERN has a formal review and approval process for all LHC experiments
  - Large Hadron Collider Committee/Upgrade Cost Group (LHCC/UCG) have final approval
  - Overall responsibility for CMS QA is held by the international CMS collaboration.
    - The CMS Technical Coordinator – Austin Ball, appointed by CERN, holds overall responsibility for all CMS activities.

CMS Organization – QA Roles

Upgrade Project Coordinator

Technical Coordination (ESH&Q)



QAP Section 4: CERN/CMS Approval Process

- Highlights of the international CMS review & approval
  - Determination of technical requirements
  - Standard technical or engineering design reviews, procurement readiness reviews, etc. during R&D and pre-production
  - Compliant with all relevant codes and standards
  - Approvals of QA activities, readiness reviews, and acceptance reviews during production and installation
- Approvals are scheduled at four steps of the project (Like Critical Decisions):
  - Step 1 – Initial Design (Technical proposal)
  - Step 2 – Baseline Design (Detailed Technical Design)
  - Step 3 – Final Design / Construction Readiness
  - Step 4 – Project Completion/Operations Readiness

The formal approval process is described in the LHC Experiments Phase II Upgrades Approval Process [CERN LHCC-2015-007]

QAP Section 5:
CERN/CMS Oversight Roles / Responsibilities

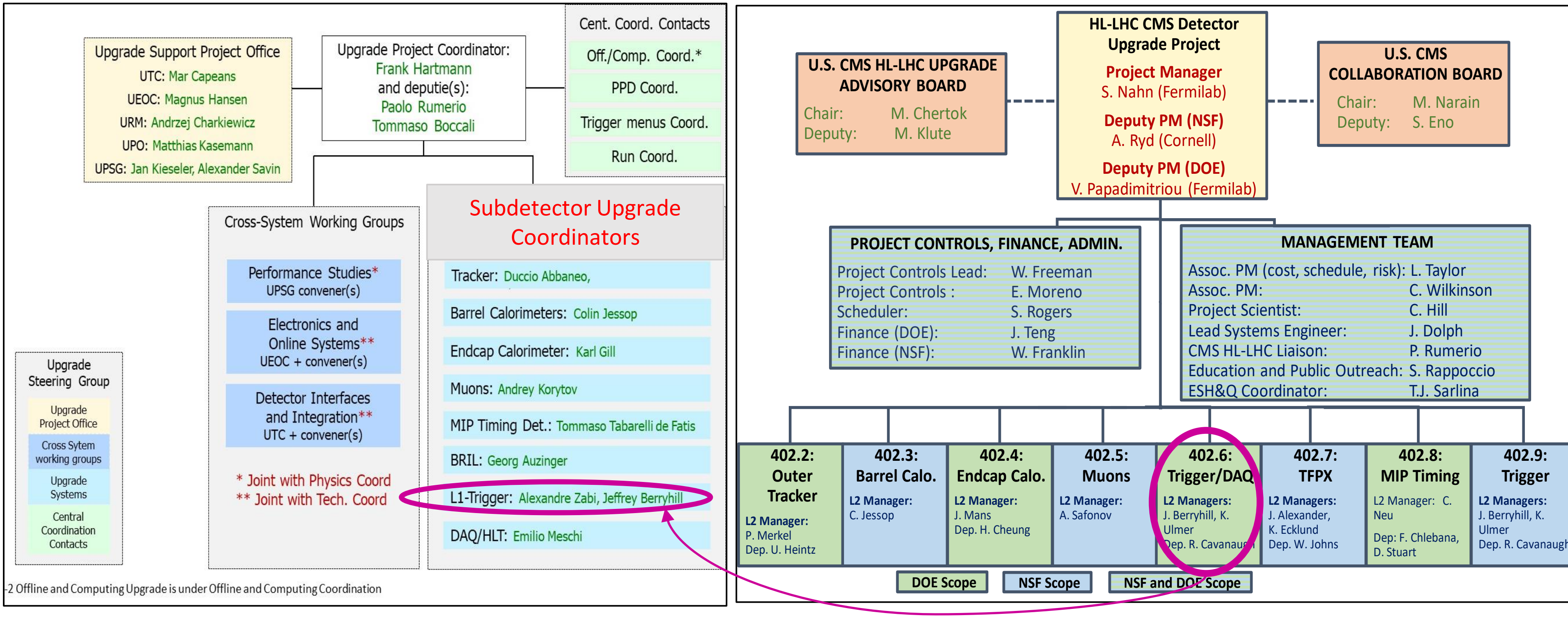
- CERN LHCC/UCG
  - Approve plans for QA as part of Step 2 baseline design approval and at Step 3 for detailed implementation approval.
- CMS Upgrade Coordination Lead
  - Calls for and conducts the CMS internal reviews leading to Step 2
  - Works with the CMS TC for reviews leading to Step 3.
- CMS Upgrade Technical Coordinator (UTC) and Electronics Coordination (UEC) Leads
  - Keep up-to-date drawings and ensure inter-compatibility between CMS subcomponents and LHC infrastructure.
  - Participate in planning/coordination of QA activities and metrics.
  - Call for reviews of all subprojects leading to Step 3
  - Maintain technical documentation in the CMS EDMS or DocDB document systems, including specifications and QA procedures.

QAP Section 5: CMS Subdetector Roles and Responsibilities

- CMS Subdetector Upgrade Coordinators
  - Oversight and management of each integrated detector subsystem, including efforts from all contributors.
- CMS Subdetector QA Managers (assigned by CMS)
  - Coordinate of QA processes across all participating institutions for that subdetector.
  - Responsible for defining or approving assembly/test procedures for each component or subassembly
  - Maintain common data-base and tracking tools for grading, performance matching, and history tracking

U.S. CMS Roles in CMS HL-LHC Upgrade Project

CMS Upgrade Organization | U.S. Upgrade Organization



- QA procedures for each CMS subdetector (e.g. L1 Trigger) established by relevant CMS Subdetector Upgrade Coordinator
- Corresponding U.S. CMS subproject L2 manager (e.g. 402.6) responsible for implementation, documentation, etc. within U.S. project to satisfy CMS requirements and U.S. project/DOE requisites
- Facilitated by the integration of U.S CMS with CMS management
  - Trigger/DAQ Example Shown: CMS Subdetector Upgrade Coordinator is the U.S. CMS L2 manager

QAP Section 5: U.S. Roles and Responsibilities

- Project Manager (and deputies)
  - Ultimate QA responsibility for U.S. scope
- Project Scientist
  - Supports planning and provide review of the Quality Tests and Inspections developed by the WBS Level 2, 3, & 4 managers/leads
  - Works with Subproject Leads and QA Coordinator to ensure technical requirements are met
- Subproject Leads (WBS L2, L3, L4)
  - Responsible for QA/QC for their scope of work
- QA Coordinator
  - Provides planning support & review/surveillance of participating institution QA procedures **QA Finding 2**
  - Can draw on additional FNAL ESH&Q staff as needed
- QA contact at participating institutions
  - Responsible for QA/QC for their scope of work and communication with Subproject leads **QA Finding 2**

QA Plan Section 6: U.S. QA Efforts

- Details the U.S. QA efforts
  - Personnel Qualifications and Training
  - CMS Requirements and Quality Validation
  - Design & Production Work Processes and Controls
  - Software Quality Assurance Guidelines
  - Procurements (In line with institutional requirements)
  - Acceptance Inspection and Testing
  - Shipping Requirements
  - Issue Tracking via Fermilab iTrack program
  - Documents and Records
  - Technical and Management Assessments
  - Control of Suspect/Counterfeit Items (S/CI)
  - Lessons Learned

QAP Subproject Appendix

- The QAP appendix contains high level descriptions of QA implementation specific to each L2 U.S. CMS subproject, including:
  - Short description of the types of deliverables (designs, hardware, software, test results, etc.)
  - Subdetector organization and communication methods within CMS and U.S. CMS
  - Short over-view of the types of QA activities (electronic prototyping, simulations or other modeling, material testing, procurement, assembly, QC, performance testing, etc.)
  - List of participating institutions
  - Management of non-conforming parts
  - Document and Record keeping

Subproject QA/QC Activity Spreadsheets

- Summary of QA/QC Activities by subproject, including acceptance tests to verify that deliverables meet design performance specifications.
  - Activity titles and descriptions
  - Assigned responsibilities/contacts
  - Flowdown links to technical engineering and/or scientific requirements
  - References to related QA/QC procedures, hardware, training, calibrations
  - Working documents expected to evolve and mature with design efforts

QA Activity Sheets posted with subproject Requirements Documents:
Outer Tracker Forward Pixels CMS-doc-13388
Endcap Calorimeter CMS-doc-13447
Trigger/DAQ CMS-doc-13318
MIP Timing Layer CMS-doc-13536

Sample QA/QC Activity Spreadsheet (1)

- Endcap Calorimeter
  - WBS, Responsibilities and contacts, QA Activity IDs and titles, and technical requirement references

WBS	WBS Title	L2, L3, L4 Lead	QA/QC Activity Name	Responsible Institution	QA/QC Coordinator/ Contact	QA/QC Activity ID	Quality Control or Assurance Activity/ Parameter	Specification(s)	Requirement ID	Requirement Title
402.04.03	Sensors	N. Akchurin, R. Yohay	Neutron Irradiation	Brown, TTU	Hinton	CE-QA-006	Measurement	[sensor supplier (or CERN) spec dwg/doc numbers assuming that after rad test sensors must still meet spec]	CE-engr-021	CE sensor radiation hardness
402.04.03	Sensors	N. Akchurin, R. Yohay	Proton Irradiation	FNAL	R. Yohay	CE-QA-007	Measurement	[sensor supplier (or CERN) spec dwg/doc numbers assuming that after rad test sensors must still meet spec]	CE-engr-021	CE sensor radiation hardness
402.04.04.04-06	Module Assembly	N. Akchurin, M. Paulini	Visual Inspection	UCSB/TTU/CMU	L3s	CE-QC-008	Monitoring	multiple engineering specification drawings and documents	CE-engr-006	CE System Integration and Maintainability
402.04.04.01.03	Module PCB	M. Paulini, K. Kaadze	Acceptance Testing	KSU	K. Kaadze	CE-QC-009	Measurement	[PCBs dwg/doc numbers]	CE-engr-027, CE-engr-028, CE-engr-041	CE silicon module PCB features has to match those of the silicon sensor within tolerance; CE silicon module PCB wirebonding pads; silicon module able to operate at -30C and tolerate thermal cycling.
402.04.04-06	Module Assembly	N. Akchurin, M. Paulini	Acceptance Testing	UCSB/TTU/CMU	L3s	CE-QC-010	Measurement	[module components top dwg/doc numbers]	CE-engr-006	CE System Integration and Maintainability
402.04.04-06	Module Assembly	N. Akchurin, M. Paulini	Standardized Assembly	UCSB	J. Incandela, S. Gyre	CE-QA-011	Process Control	multiple engineering specification drawings and documents	CE-engr-006	CE System Integration and Maintainability
402.04.04-06	Module Assembly	N. Akchurin, M. Paulini	Acceptance Testing	UCSB/TTU/CMU	L3s	CE-QC-012	Measurement	[module top dwg/doc numbers]	CE-engr-041, CE-engr-045,CE-engr-048	silicon module able to operate at -30C and tolerate thermal cycling; Robust sensor connections and HV standoff, Alignment precision for the module layers is 25 microns

Sample QA/QC Activity Spreadsheet (2)

- EndCap Calorimeter (cont.)
  - QA/QC process descriptions, procedures, calibrations, records, training

QA/QC Activity Name	QA/QC Activity ID	(QA) Validation Activities	(QC) Inspection / Acceptance Tests	Measurement/ Method	Associated Hardware/ Software	Standard / Procedure / Process Doc	Calibration Planning	Record (Data, Calibration, etc.)	Training and Qualifications
Neutron Irradiation	CE-QA-006	Sample of sensors irradiated with neutrons to verify radiation tolerance	NA	Neutron Irradiation and evaluation is carried out on a subset of sensors per batch to ensure radiation tolerance throughout production	Access to RINSC, post-irradiation Sensor/Process QC tests	[neutron rad test procedure doc number]	Neutron Flux and Energy spectrum calibrated periodically	Test results stored in database, available through etraveler	Irradiation done professionally, evaluation as above
Proton Irradiation	CE-QA-007	Sample of sensors irradiated with protons to verify radiation tolerance	NA	Proton Irradiation and evaluation is carried out on a subset of sensors per batch to ensure radiation tolerance throughout production	FSU linac, FNAL ITA, post-irradiation testing	[Proton rad test procedure document number]	N/A	Test results stored in database, available through etraveler	Irradiation done professionally, evaluation as above
Visual Inspection	CE-QC-008	NA	Visual inspection of mechanical and electrical components before use in assembly	All components will be visually inspected at the Assembly Sites before entering the assembly chain	Microscope	https://twiki.cern.ch/twiki/bin/view/CMS/HGCALModuleTesting	N/A	Visual inspection results stored in database, available in etraveler	Short learning period to be able to identify substandard fabrication (discoloration, poor traces, etc.)
Acceptance Testing	CE-QC-009	NA	Electrical testing and thermal cycling of readout PCBs before integration into modules; Validation of PCB functionality before module assembly including thermal cycling and burn-in	PCBs will be tested at a common point using standard test systems before shipment to module assembly sites. Test will include thermal cycling of the PCBs, visual inspection, etc.	Module test system, thermal cycling system	https://twiki.cern.ch/twiki/bin/view/CMS/HGCALModuleTesting	N/A	Test results stored in database, available through etraveler	No special skills but training required on test systems
Acceptance Testing	CE-QC-010	NA	Verification of component functionality before integration into Modules:	Components will be acceptance tested at the Assembly Sites before entering the assembly chain	Component test systems	https://twiki.cern.ch/twiki/bin/view/CMS/HGCALModuleTesting	Standard-candle components will be used to verify testing capabilities	Test results stored in database, available through etraveler	No special skills but training required on test systems
Standardized Assembly	CE-QA-011	Assembly at different sites will follow identical procedures	NA	Fully specified and documented Assembly procedures followed at all sites, identical tooling sets used for module assembly, cross-site calibrations	N/A	https://twiki.cern.ch/twiki/bin/view/CMS/HGCALModuleAssembly	N/A	Official procedures will be under document control	Clearly assembly requires skilled technicians
Acceptance Testing	CE-QC-012	NA	Validation of module dimensions, features, functionality, and robustness before shipping to cassette assembly site.	Modules will be acceptance tested and graded at the Assembly Sites before shipping to the cassette assembly site. Visual inspection, OGP measurements of the module features, thickness, and flatness, and functionality testing with a standard module test stand. Tests will be done both before and after thermal cycling and burn-in.	OGP, Module test system, thermal cycling system.	https://twiki.cern.ch/twiki/bin/view/CMS/HGCALModuleTesting, example from previous project is Phase 1 FPIX module testing procedures CMS-DocDB-12690	N/A	Test results stored in database, available through etraveler	QC work requires technician trained in use of existing testing systems

Subcomponent QA/QC Plans and Procedures

- Detailed QA/QC plans, procedures, and acceptance tests and processes
  - Many based on previous work: initial construction, phase 1 upgrades, or HL-LHC upgrade prototyping
  - Some provided to U.S. CMS by the CMS collaboration
  - All U.S. plans written in collaboration with or approved by CMS
  - Finalized as design efforts and production planning mature

Samples of existing QA/QC plans

QA/QC TEST PLAN DOCUMENT	CMS HL-LHC DocDB Project Document No. CMS-doc-13318
	Trigger and DAQ System QA/QC Te Plan
	Page 1
	Revision: B · Date: 07-October-2

Trigger and DAQ (WBS 402.06 and 402.09) QA/QC Test Plan

NOTE:
The most recent DocDB version of this document is the ONLY controlled record of this document.
Refer to CMS-doc-13318
This document is only to be revised by the Trigger and DAQ (WBS 402.06 and 402.09) Manager or Systems Engineer

Abstract
The purpose of this document is to describe how the Trigger Boards will be tested to show that it meets its design and functional requirements.
.

Prepared by:	Checked by:	Approved by:
Richard Cavanaugh	J. Dolph	J. Berryhill K. Ulmer
L2 Systems Engineer(s)	Lead Systems Engineer	L2 Manager(s)

Revision status recorded in:
CMS-doc-13318

This page will contain documentation for testing High-Granularity Calorimeter (HGCal) modules and components

If you have questions that aren't covered here, please check the FAQ page. If your question is not answered there, feel free to post it in the Q&A page (if it's not already there.)

Page Contents

HGCAL Module Assembly &Testing

Component testing

Baseplate-kapton leakage

PCB testing

Module testing

Standard IV curve and DAQ

Burn-in

Thermal testing

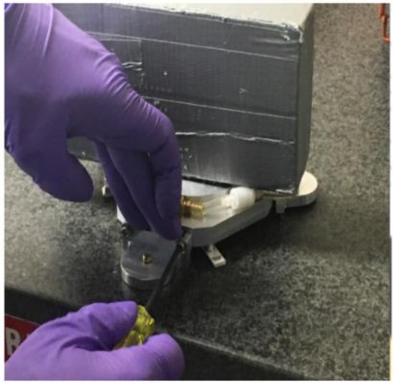
Thermal cycling

-- BrunelConstantineOdegard - 2019-02-26

PCB application

To place the PCB, we now set the height of the tool to the thickness of the PCB+the glue layer between the sensor+ the sensor & kapton baseplate. We can do th again by using the cera gauge blocks as shown below.

Once the tool height has been checked, check that the height is properly set by swiping the cera blocks under the tool to make sure the height is even.



Wire Bonding Assembly &Testing

Wirebonding

Wire bonding connects the layers of the module electronically with wires. The basic steps to wire bonding are:

- **Pre-bonding Inspection:** A brief microscopic review of the module after the gluing step looking for issues with bond pads, glue spillage, or PCB damage.
- **Test Bonds:** During early production, each module is a candidate for creating test bonds and evaluating their strength with the pull tester. During full production, every 10th module will undergo this step. After pull testing all test wires are removed.
- **Wirebonding Program Run:** Execution of the wirebond program by the machine. Troubleshoot as needed if the machine encounters an error and stops.
- **Post-bonding Inspection:** A microscopic review of all wire bonds. Any missed bonds will need to be corrected.
- **Bond Repair:** Returning the module to the bond machine if needed to replace wires.
- **Documentation:** Each of these steps is logged in the database with time, date, and initials of the user.

Current standard operating procedures from Summer 2019:

- Run Wirebond Program checklist Run_Wirebond_Program_twiki_version.docx
- Pull testing checklist Pull_Testing_twiki_version.docx

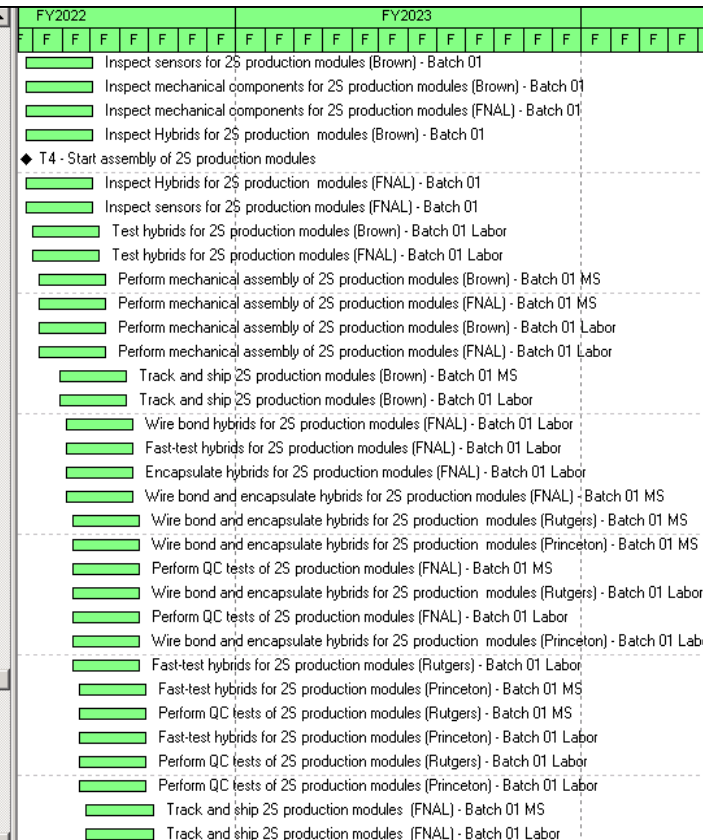
QA/QC Activities Cost and Schedule

- QA/QC activities are integrated into the Resource Loaded Schedule (RLS)
  - Schedule activities: Readiness reviews, prototyping, materials testing, acceptance QA/QC, performance testing, acceptance reviews, etc.
  - P6 schedule (RLS) includes cost and labor for QA activities

QA/QC activities highlighted in blue

402.2 - Outer Tracker Example - 2S Module Production – Batch 01

Activity Name	Duration	Start	Finish	FNAL Hrs	Univ Hrs	FNAL Labor Cost	Univ Labor Cost	Material Cost	Resp Inst.
Inspect sensors for 2S production modules (Brown) - Batch 01	50d	22-Feb-22	02-May-22	0	35	$0	$984	$0	BR
Inspect mechanical components for 2S production modules (Brown) - Batch 01	50d	22-Feb-22	02-May-22	0	24	$0	$675	$0	BR
Inspect mechanical components for 2S production modules (FNAL) - Batch 01	50d	22-Feb-22	02-May-22	24	0	$0	$0	$0	FN
Inspect Hybrids for 2S production modules (Brown) - Batch 01	50d	22-Feb-22	02-May-22	0	21	$0	$1,434	$0	BR
T4 - Start assembly of 2S production modules	0d	22-Feb-22		0	0	$0	$0	$0	
Inspect Hybrids for 2S production modules (FNAL) - Batch 01	50d	22-Feb-22	02-May-22	21	0	$1,588	$0	$0	FN
Inspect sensors for 2S production modules (FNAL) - Batch 01	50d	22-Feb-22	02-May-22	35	0	$0	$0	$0	FN
Test hybrids for 2S production modules (Brown) - Batch 01 Labor	50d	01-Mar-22	09-May-22	0	132	$0	$5,546	$0	BR
Test hybrids for 2S production modules (FNAL) - Batch 01 Labor	50d	01-Mar-22	09-May-22	32	0	$3,816	$0	$0	FN
Perform mechanical assembly of 2S production modules (Brown) - Batch 01 MS	50d	08-Mar-22	16-May-22	0	0	$0	$0	$3,001	BR
Perform mechanical assembly of 2S production modules (FNAL) - Batch 01 MS	50d	08-Mar-22	16-May-22	0	0	$0	$0	$1,895	FN
Perform mechanical assembly of 2S production modules (Brown) - Batch 01 Labor	50d	08-Mar-22	16-May-22	0	682	$0	$44,832	$0	BR
Perform mechanical assembly of 2S production modules (FNAL) - Batch 01 Labor	50d	08-Mar-22	16-May-22	462	0	$51,493	$0	$0	FN
Track and ship 2S production modules (Brown) - Batch 01 MS	50d	29-Mar-22	07-Jun-22	0	0	$0	$0	$3,864	BR
Track and ship 2S production modules (Brown) - Batch 01 Labor	50d	29-Mar-22	07-Jun-22	0	21	$0	$1,698	$0	BR
Wire bond hybrids for 2S production modules (FNAL) - Batch 01 Labor	50d	05-Apr-22	14-Jun-22	221	0	$21,939	$0	$0	FN
Fast-test hybrids for 2S production modules (FNAL) - Batch 01 Labor	50d	05-Apr-22	14-Jun-22	32	0	$0	$0	$0	FN
Encapsulate hybrids for 2S production modules (FNAL) - Batch 01 Labor	50d	05-Apr-22	14-Jun-22	53	0	$5,261	$0	$0	FN
Wire bond and encapsulate hybrids for 2S production modules (FNAL) - Batch 01 MS	50d	05-Apr-22	14-Jun-22	0	0	$0	$0	$1,895	FN
Wire bond and encapsulate hybrids for 2S production modules (Rutgers) - Batch 01 MS	50d	12-Apr-22	21-Jun-22	0	0	$0	$0	$1,466	RU
Wire bond and encapsulate hybrids for 2S production modules (Princeton) - Batch 01 MS	50d	12-Apr-22	21-Jun-22	0	0	$0	$0	$1,523	PU
Perform QC tests of 2S production modules (FNAL) - Batch 01 MS	50d	12-Apr-22	21-Jun-22	0	0	$0	$0	$0	FN
Wire bond and encapsulate hybrids for 2S production modules (Rutgers) - Batch 01 Labor	50d	12-Apr-22	21-Jun-22	0	137	$0	$11,242	$0	RU
Perform QC tests of 2S production modules (FNAL) - Batch 01 Labor	50d	12-Apr-22	21-Jun-22	11	0	$0	$0	$0	FN
Wire bond and encapsulate hybrids for 2S production modules (Princeton) - Batch 01 Labor	50d	12-Apr-22	21-Jun-22	0	137	$0	$16,933	$0	PU
Fast-test hybrids for 2S production modules (Rutgers) - Batch 01 Labor	50d	12-Apr-22	21-Jun-22	0	16	$0	$1,313	$0	RU
Fast-test hybrids for 2S production modules (Princeton) - Batch 01 MS	50d	19-Apr-22	28-Jun-22	0	0	$0	$0	$0	PU
Perform QC tests of 2S production modules (Rutgers) - Batch 01 MS	50d	19-Apr-22	28-Jun-22	0	0	$0	$0	$0	RU
Fast-test hybrids for 2S production modules (Princeton) - Batch 01 Labor	50d	19-Apr-22	28-Jun-22	0	16	$0	$1,978	$0	PU
Perform QC tests of 2S production modules (Rutgers) - Batch 01 Labor	50d	19-Apr-22	28-Jun-22	0	138	$0	$3,977	$0	RU
Perform QC tests of 2S production modules (Princeton) - Batch 01 Labor	50d	19-Apr-22	28-Jun-22	0	138	$0	$3,694	$0	PU
Track and ship 2S production modules (FNAL) - Batch 01 MS	50d	26-Apr-22	06-Jul-22	0	0	$0	$0	$3,672	FN
Track and ship 2S production modules (FNAL) - Batch 01 Labor	50d	26-Apr-22	06-Jul-22	21	0	$2,085	$0	$0	FN



Response to Previous Reviews

Charge 8

2018 IPR: *Institutional QA/QC plans, roles, and oversight not clearly defined*

QA Finding 1

- ***The Quality Assurance (QA) Plan, prepared in May 2018, relies heavily on CMS processes and specifies that each institution will have its own QA plan. The institutional plans were not presented or available for review. QA evaluation and oversight for institutions must be clearly defined and include any CERN qualification steps by defining sequence and prerequisites.***

QA Finding 2

- ***Similarly, the university/institutional ES&H plan coordination, review, and acceptance/ concurrence process and criteria is not defined. The Integrated Safety Management and QA plans need to clearly define the role of the project in the review and coordination and oversight of institution ES&H and QA plans.***

Efforts since the 2018 IPR

- QAP revised
- QAP Section 7 clarifies U.S. QA/QC institutional plans and roles within the CMS framework
- QAP appendices and spreadsheets updated; QA/QC activities linked to requirements
- Held dedicated ESH&Q review Nov. 29, 2018 to ensure that we addressed concerns

Response to Previous Reviews

Charge 8

2018 ESH&Q Review: ***The QAP needs to address the packaging and shipping requirements for components to be sent to CERN.***

- **Added Section 6.10 on Shipping Requirements to the QAP**

2019 DR: ***ESH&Q aspects have been addressed***

- ***The QAP is thorough and ready for CD-1***

QAP Section 7: QA Oversight for Participating Organizations

Charge 8

All participating U.S. CMS institutions must follow QA plans that satisfy CMS Subdetector requirements and the QAP.

- QA plans and procedures created collaboratively QA Finding 1
  - U.S. L2, L3, L4 leads work with institutional technical and QA representatives and the US CMS QA Coordinator
  - U.S. leads ensure adherence to CMS requirements and approved procedures, subject to CMS review and approval process
  - Includes work under subawards to vendors or other participating institutions.
  - Institution staff responsible for verifying compatibility of QA/QC plans to local institutional QA programs
- L2 lead and the US CMS QA Coordinator review and approve the QA plans and monitor/verify compliance. QA Finding 2
  - Most plans are still in development as production readiness advances
  - Site visits may be required for QA plan approval and surveillance

List of Participating Institution Site Audits

- Preliminary ESH&Q Site visits have started (Reports **CMS-doc-13856**)
  - UCSB site visit reports for ESH and QA - July 2019.
  - Fermilab site visit reports for ESH and QA - August 2019.
  - Rutgers, Princeton, Brown site visit reports for ESH and QA - September 2019.

Charge 8

QA Finding 2

WBS #	WBS Description	Facilities
402.02.03	Outer Tracker: Sensors	Brown, Rochester, Fermilab
402.02.04	Outer Tracker: Electronics	Fermilab, Princeton, Rutgers
402.02.05	Outer Tracker: Modules	Brown, Fermilab, Princeton, , Rutgers
402.02.06	Outer Tracker: Flat Barrel Mechanics	Fermilab
402.02.07	Outer Tracker: Integration	Fermilab
402.04.03	Calorimeter Endcap: Sensors	Brown, Fermilab, Texas Tech, FSU
402.04.04	Calorimeter Endcap: Modules	Carnegie Mellon, Texas Tech, UC Santa Barbara
402.04.05	Calorimeter Endcap: Cassettes	Fermilab, Minnesota
402.04.06	Calorimeter Endcap: Scintillator Caorimetry	Fermilab, FSU, Maryland, NIU, Rochester
402.04.07	Calorimeter Endcap: Electronics and Services	Fermilab, Minnesota
402.06.03	Trigger / DAQ: Cal Trigger	Wisconsin
402.06.05	Trigger / DAQ: Correlator Trigger	Wisconsin
402.06.06	Trigger / DAQ: DAQ	Fermilab
402.08.03	Timing Layer: Barrel Timing Layer	Virginia, Caltech, KSU
402.08.04	Timing Layer: Endcap Timing Layer	Fermilab, Nebraska, Kansas

HL-LHC US CMS

Site Field Audit Checklist

Charge 8

QA Finding 2

- **Sample QA Audit Report for UCSB.** CMS-doc-13856

US-HL-CMS Quality Assurance Audit Site Visit Checklist

WBS 402.4 HGCal Module Group-UCSB *Date: 2 July 2019*

Contacts: ***Suzanne Kyre, Dano Pagenkopf, Joe Incandela*** *Location:* **UC Santa Barbara**

1.	Material/Component Receipt and Shipment	Satisfactory	In Progress	No
	Have acceptance criteria been defined by the organization?	X		
	Are the criteria written down, approved, and entered into a database?		X	
	Did the criteria change over time with documentation entered into a database?		X	
	If changes have occurred, have they been approved by appropriate authority?	X		
	Is data transmitted from last organization in a timely way and is it useful?	X		
	Do written procedures exist and are they followed?		X	
	Are personnel properly trained to conduct acceptance checks?	X		
	Are the results being documented in a consistent manner?	X		
	Are test results entered into a database or to a traveler?	X		
	Is all measuring and test equipment properly calibrated?			X
	Are components stored in secure/segregated locations to prevent damage or loss?	X		
	Have shipping requirements been defined to prevent damage during transport?	X		
2.	**Quarantine of Deficient or Non-Conforming Product**	**Satisfactory**	**In Progress**	**No**
	Are storage areas properly identified?	X		
	Is product labeling clearly visible and consistent?		X	
	Have non-conformance procedures been written and approved?			X
3.	**Personnel Training**	**Satisfactory**	**In Progress**	**No**
	Do current, written procedures exist for each process?		X	
	Do posted instructions agree with authorized, written procedures?		X	
	Is there a process for informing or re-training workers when procedures change?	X		
	Are procedural changes reviewed for impact on the final product?	X		
4.	**Acceptance Criteria For Finished Product**	**Satisfactory**	**In Progress**	**No**
	Have acceptance criteria been defined by the organization?	X		
	Are the criteria written down, approved, and entered into a formal document?	X		
	Have updated acceptance specs been approved and documented?	X		
	Have storage requirements been defined to prevent damage?	X		
5.	**Records, Logs, and Databases**	**Satisfactory**	**In Progress**	**No**
	Have standard forms/spreadsheets been created to record data?	X		
	Is information entered in a timely and consistent manner?	X		
	Has the information been entered into a database?		X	
	Are paper copies stored in an organized and secure manner?	X		
	Are local databases backed up to prevent loss of data in the event of a failure?			X
	Is data available to personnel outside the originating institution?	X		

- L2 and U.S. CMS ESH&Q Coordinator visit sites to review ESH&Q as necessary.
- Site Visit QA Audit Checklist Template CMS-doc-13668

Notes and Observations:

1. **Material/Component Receipt and Shipment**
   - Three main components are received from commercial vendors: the base plates, sensors, and printed circuit boards (PCBs). Visual inspections are performed on all components and the PCBs will be tested electronically at some level. A percentage of baseplates will be checked for flatness against fabrication drawings. CERN database will be the official repository but, for the moment, the CERN DocDB is the current repository as the final database is not yet ready to accept data.
   - Mechanical and electrical tests will be performed after fabrication and the acceptable modules will be shipped to either Fermilab or CERN to be assembled into cassettes. Additional tests will be performed at the cassette assembly sites to verify that nothing has been damaged during shipment.
   - Procedures are still being developed and refined by the group. Database development is in progress with travelers currently being used to document component properties.
   - Finished product acceptance criteria are well understood at this point for items being produced for a specific purpose (not in production phase yet).
   - Shipping containers have been designed for the 8-inch modules based on a previous design for the 6 inch modules. A retrofit is necessary to expand the boxes and the design will be shared with the other 5 fabrication sites.

HGCal Module Assembly

Recommendations:

1. Schedule the recalibration of the OGP with the manufacturer.
2. Determine a single location for procedures that allows for version control so that personnel know where to find the current version if necessary.
3. Procedures should be edited to remove vague language and excess narrative. Checklists should be considered to provide clear, step by step instructions and to better highlight danger/caution steps.
4. Verify that all computers used for the CMS upgrade project are backed up in a timely and reliable manner.
5. Define a central repository for drawings that has version control and require all sites to make use of it.

Summary

- Quality Assurance Plan updated and finalized: signed & posted **Charge 7**
- Capable management team in place
  - QA leads assigned, with defined organization, roles, and responsibilities
- QA policies are established & applied consistently throughout project
  - Quality Assurance controls defined from CERN/CMS through Fermilab to U.S. participating institutions
  - Applied consistently to all participating U.S. efforts (NSF and DOE)
- Documented QA/QC activities to verify that performance is met
  - Activity spreadsheets and procedures (on-going procedure development)
  - Flowdown captured from technical requirements to QA/QC Activities
  - QA/QC activities integrated into RLS (P6) schedule and budget
- All previous review recommendations addressed **Charge 8**

QA/QC Plan ready for CD-1