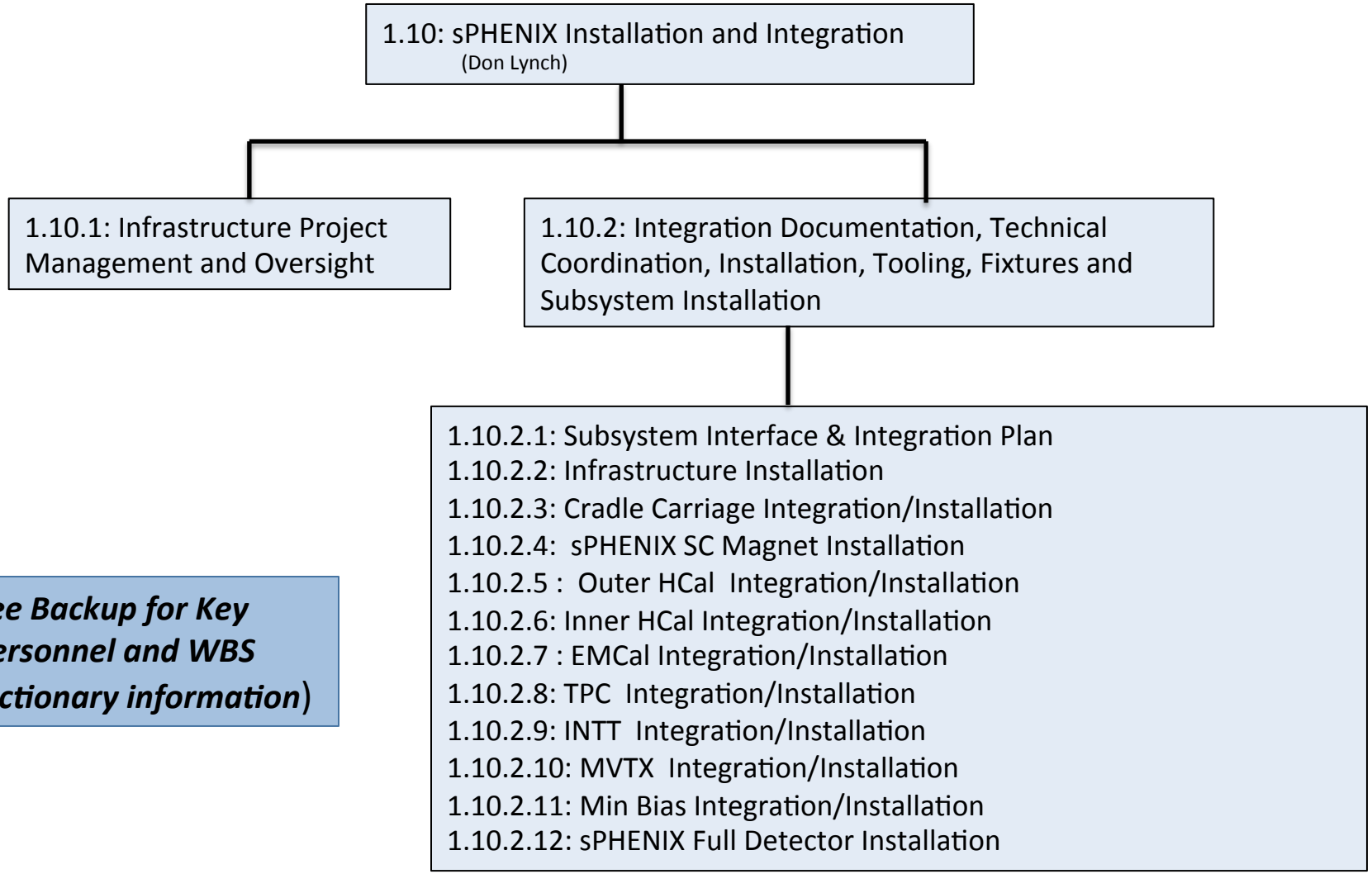
sPHENIX Director's Review

August 2-4, 2017

BNL

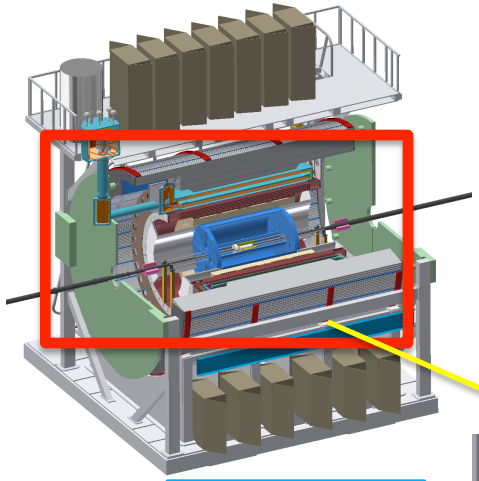
Don Lynch

WBS Structure & Control Accounts



See Backup for Key Personnel and WBS dictionary information)

System Description



Installation Requirements

- IR & AH Floor **Loading Limits**: 4000 psi, max
- Installation to be accomplished in the Assembly Hall (**40 ton and 5 ton overhead cranes**) until TPC is installed then assembly is moved to IR for installation of BP (beampipe), INTT, MVTX and Min Bias
- **Overall size requirements** The complete sPHENIX assembly, including magnet valve box stack and all electronics racks, must fit through the sPHENIX sill on the existing sPHENIX rail system
- Infrastructure defines most interfaces (except installation tooling and fixtures interfaces)
- **Alignment precision**: defined in ICD's which link each subsystem with the Installation/ Integration Effort
- **Commissioning** of all subsystems separately and as a system (without beam)

Parallel Activities

INTT

MVTX

sPHENIX MIE

OUTER HCAL

INNER HCAL

EMCAL

TPC

MIN BIAS

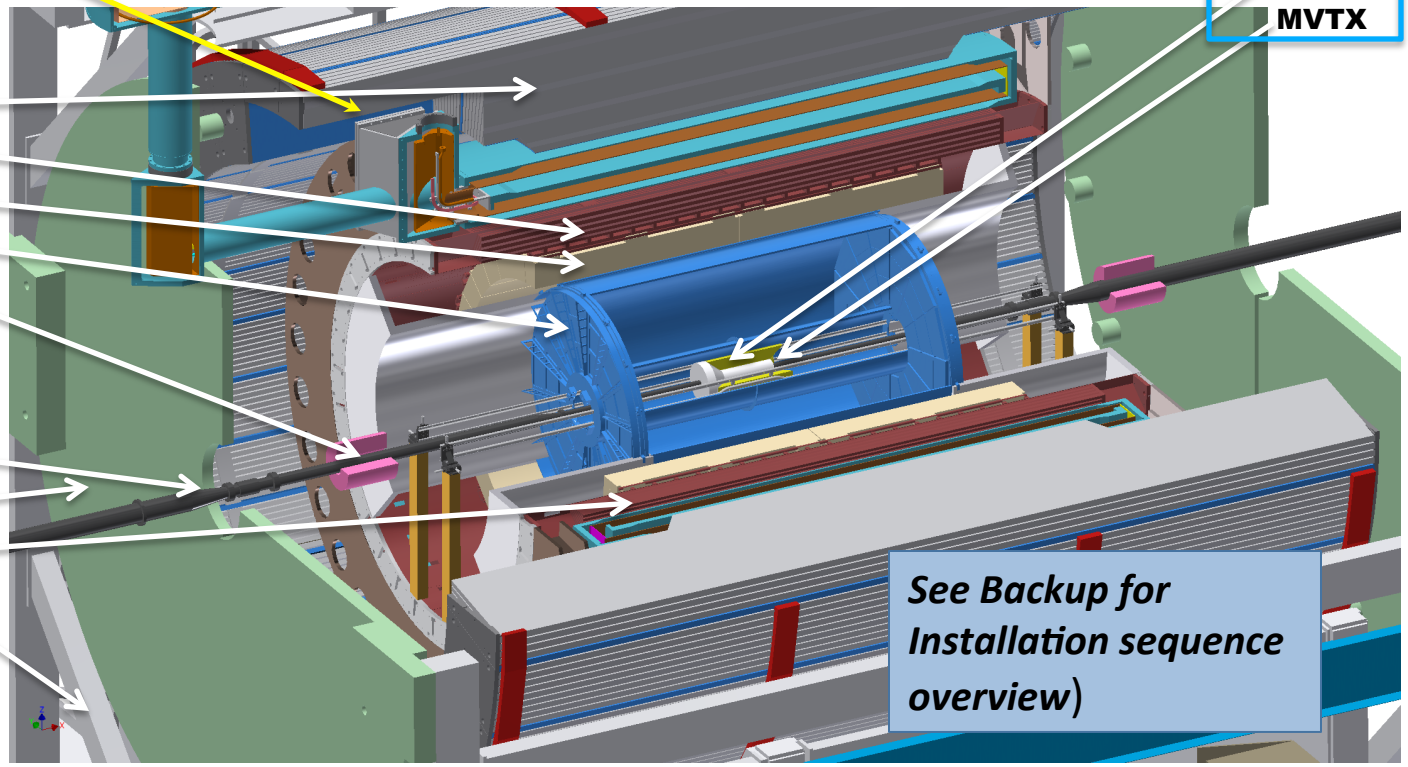
BEAM PIPE

END CAP/FLUX RETURN

SC MAGNET

CRADLE CARRIAGE

Infrastructure & Facility Upgrade



See Backup for Installation sequence overview)

Scope

The **Installation and Integration** of the sPHENIX detectors into the full sPHENIX System Includes the following:

- Defining the subsystem **Interface and Integration plans**, including installation procedures, work plans, integrated safety plans and all associated reviews.

(See Interface Control Documentation (ICD) slide in backup)

- Design and/or specification of all **installation tooling, fixtures** and access equipment.
- **Installation/upgrade** of common **Infrastructure** including the cradle carriage, work platforms and access, services support structure, pole tips, beam pipe, HVAC, electronics cooling water, electronics racks, safety systems and upgrades to non-IR infrastructure from PHENIX to sPHENIX requirements.
- **Installation and alignment** of all sPHENIX fully assembled, instrumented and tested subsystem components and installation of all associated services:
  - 32 Outer HCal sectors
  - Superconducting sPHENIX Magnet (formerly BABAR Magnet) (Note: cryo and electrical services installation is part of the magnet subsystem scope.)
  - Inner (inside the Magnet) detector structural supports
  - 32 Inner HCal sectors (Assembly of these sectors into the full detector prior to installation is included in this scope.)
  - 64 EMCal sectors (installed onto rails mounted to the Inner HCal)-
  - Tracking detectors (TPC, INTT and MVTX)
  - Min Bias detector
- **QA testing** of all detector components prior to and subsequent to installation
- **Commissioning** of the fully assembled sPHENIX subsystem

All detector components and detector services and services components (e.g. ***cables , fibers, piping, cooling equipment****, etc) and all support structure components including the* ***cradle carriage, inner detector support structure****, other infrastructure items, etc.) are the* ***responsibilities of the individual detector subsystems*** *and/or the infrastructure subsystem. See these infrastructure and the individual detector subsystem scope definitions to see responsibility delineation for these subsystems.*

sPHENIX Installation Status

Installation/Integration Work Package	Status	Notes
Subsystem Interface & Integration Plan	conceptual	Detailed 3D model
Infrastructure Installation	advanced conceptual	Many repurposed components
Cradle Carriage Integration/Installation	conceptual	Detailed 3D model
sPHENIX SC Magnet Installation	design	Repurposed magnet feet, modifications in design
Outer HCal Integration/Installation	design	Lifting & handling fixtures in design
Inner HCal Integration/Installation	advanced conceptual	3D model almost ready to begin design
EMCal Integration/Installation	advanced conceptual	final stages of modeling almost ready to design fixtures
TPC Integration/Installation	pre-conceptual	beginning to focus on installation and handling fixtures
INTT Integration/Installation	pre-conceptual	Still needs internal support structure analysis/design
MVTX Integration/Installation	pre-conceptual	Based on ALICE MAPS
Min Bias Integration/Installation	Advanced conceptual	Repurpose of BBC
sPHENIX Full Detector Installation	conceptual	3D model and repurposed infrastructure almost ready for design

Status key:

pre-conceptual	feasibility demonstrated, analyses in progress, options being considered
conceptual	preferred model selected, model details in progress
advanced conceptual	detailed model ready for engineering drawings
design	engineering drawings in progress
final design	drawings complete ready for review
design complete	reviews complete ready for procurement
procurement	procurement in progress
installation	subsystem installation in progress
commissioning	subsystem fully installed subsystem (non-beam) checkout in progress
operational	commissioning complete, ready for beam and data taking

Detailed 3D models, layouts and design drawings in progress

Design Drivers/ Cost Drivers

Integration & Installation Design Drivers:

- Safety
- Subsystem design requirements
- Existing infrastructure (shield wall opening, Crane coverage and limits, rail layout)
- Minimum material in active areas
- Access for repair, maintenance, upgrade
- Subsystem assembly requirements
- Subsystem support and alignment requirements

Integration & Installation Cost Drivers:

- Installation labor dominates cost
- Inner HCal Assembly Fixtures
- Outer HCal Assembly and handling fixtures
- EMCal Installation Fixtures
- TPC Installation fixtures
- Cradle/Carriage Assembly fixtures

BoE

Cost Summary

WBS #	Work Package Description	Material Cost
1.10.2.1	Subsystem Interface & Integration Plan	$0.00
1.10.2.2	Infrastructure Installation	$5,000.00
1.10.2.3	Cradle Carriage Integration/Installation	$52,500.00
1.10.2.4	sPHENIX SC Magnet Installation	$43,500.00
1.10.2.5	Outer HCal Integration/Installation	$63,500.00
1.10.2.6	Inner HCal Integration/Installation	$84,500.00
1.10.2.7	EMCal Integration/Installation	$32,500.00
1.10.2.8	TPC Integration/Installation	$33,000.00
1.10.2.9	INTT Integration/Installation	$33,000.00
1.10.2.10	MVTX Integration/Installation	$33,000.00
1.10.2.11	Min Bias Integration/Installation	$13,000.00
1.10.2.12	sPHENIX Full Detector Installation	$2,000.00
	Total Unburdened Material Cost for CA # 1.10.2 =	**$395,500.00**

Contingency

Estimates for the labor and material described in this Control account are currently based on Engineering estimates and analyses of infrastructure concepts based on evolving design of the individual subsystems. Contingency is assigned to each detail in each work package. The overall material contingency for this control account is determined by a weight averaged summation ("bottoms up") of the contingencies for the individual work packages. Labor contingency for all labor is initially assumed at a constant 25%. As the work packages' labor content becomes more well defined the individual labor contingencies for each task is reevaluated and the composite contingency calculated as weight averaged in accordance with the total estimated (unburdened) labor cost for the task.

Bottom Up Composite Labor contingency for WBS #1.10.2: Integration Documentation, Technical Coordination, Installation Tooling and Fixtures and Subsystem Installation Control Account:

Labor Contingency: 25%

Material Contingency: 36%

Resource Summary for Integration Documentation, Technical Coordination, Installation, Tooling, Fixtures and Subsystem Installation in FTE's by Resource Category

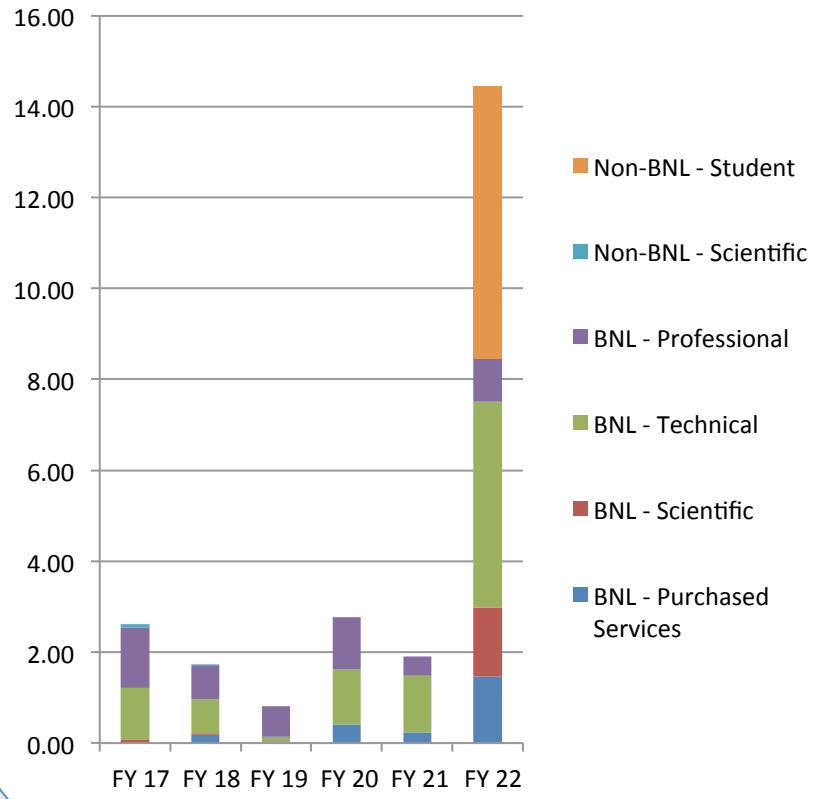
Administrators	Scientists	Engineers	Designers	Technicians	Trades	Students
0	1.7	4.8	2.1	7.0	2.4	6

BoE's for Installation work packages can be found in the review document package at:

https://sites.google.com/site/sphenixdirectorsreview/

Installation & Integration Staffing

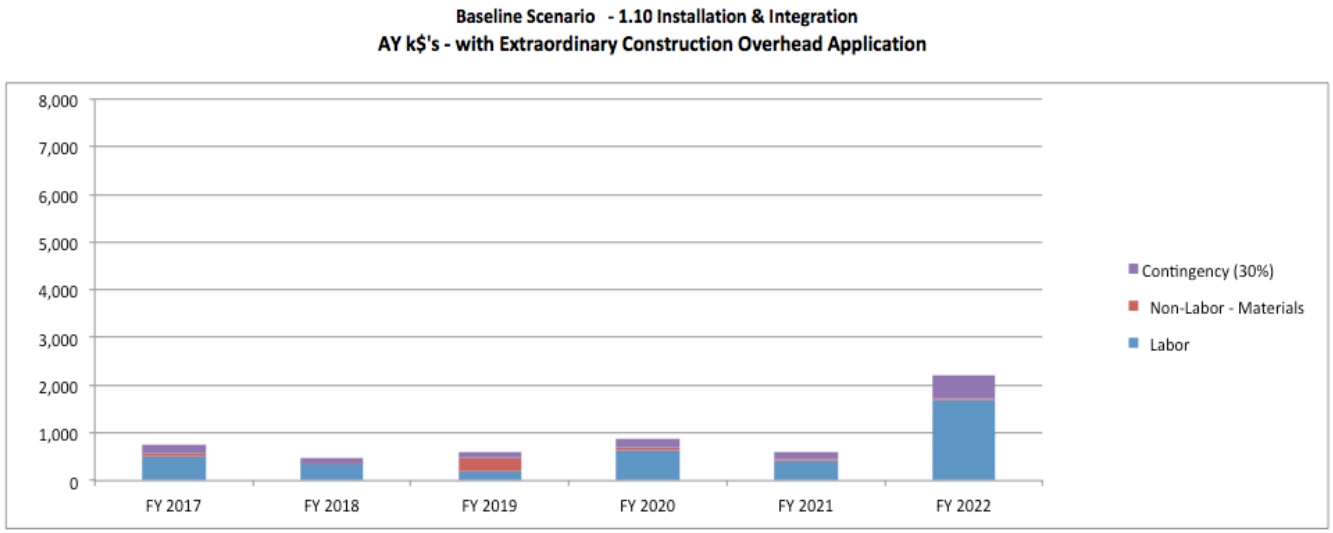
FTE Profile by Category



FTE Profile by Fiscal Year

WBS Level	Org Sort	Group	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22
1.10	BNL	Purchased Services	0.00	0.18	0.00	0.41	0.23	1.47
		Scientific	0.07	0.01	0.00	0.00	0.00	1.50
		Technical	1.14	0.78	0.15	1.21	1.26	4.53
		Professional	1.32	0.74	0.66	1.14	0.42	0.95
	BNL Sum		2.54	1.71	0.81	2.76	1.90	8.45
	Non-BNL	Scientific	0.07	0.01	0.00	0.00	0.00	0.00
		Student	0.00	0.00	0.00	0.00	0.00	6.00
	Non-BNL Sum		0.07	0.01	0.00	0.00	0.00	6.00
Grand Total			2.61	1.72	0.81	2.76	1.90	14.45

Cost Profile: Integration and Installation



Baseline Scenario
AY k$'s - with Extraordinary Construction Overhead Application

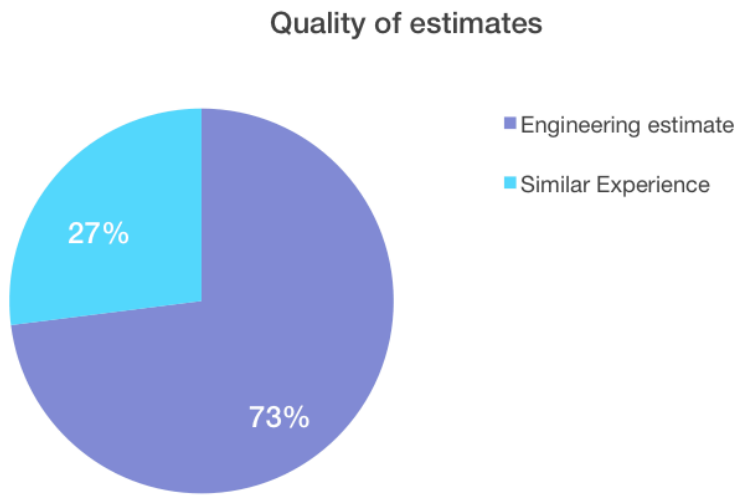
Resource	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	Total
Labor	496	357	189	633	424	1,670	3,769
Non-Labor - Materials	77	3	280	52	27	32	471
Baseline Total	573	360	469	685	451	1,702	4,240
Contingency (30%)	172	108	141	206	135	511	1,272
MIE Total	745	468	610	891	586	2213	5512

Resource	Baseline	Contingency	Total
Labor	3,769	1131	4,900
Non- Labor	471	141	612
1.10 Installation & Integration	4,240	1272	5,512

Basis of Estimate: Contingency

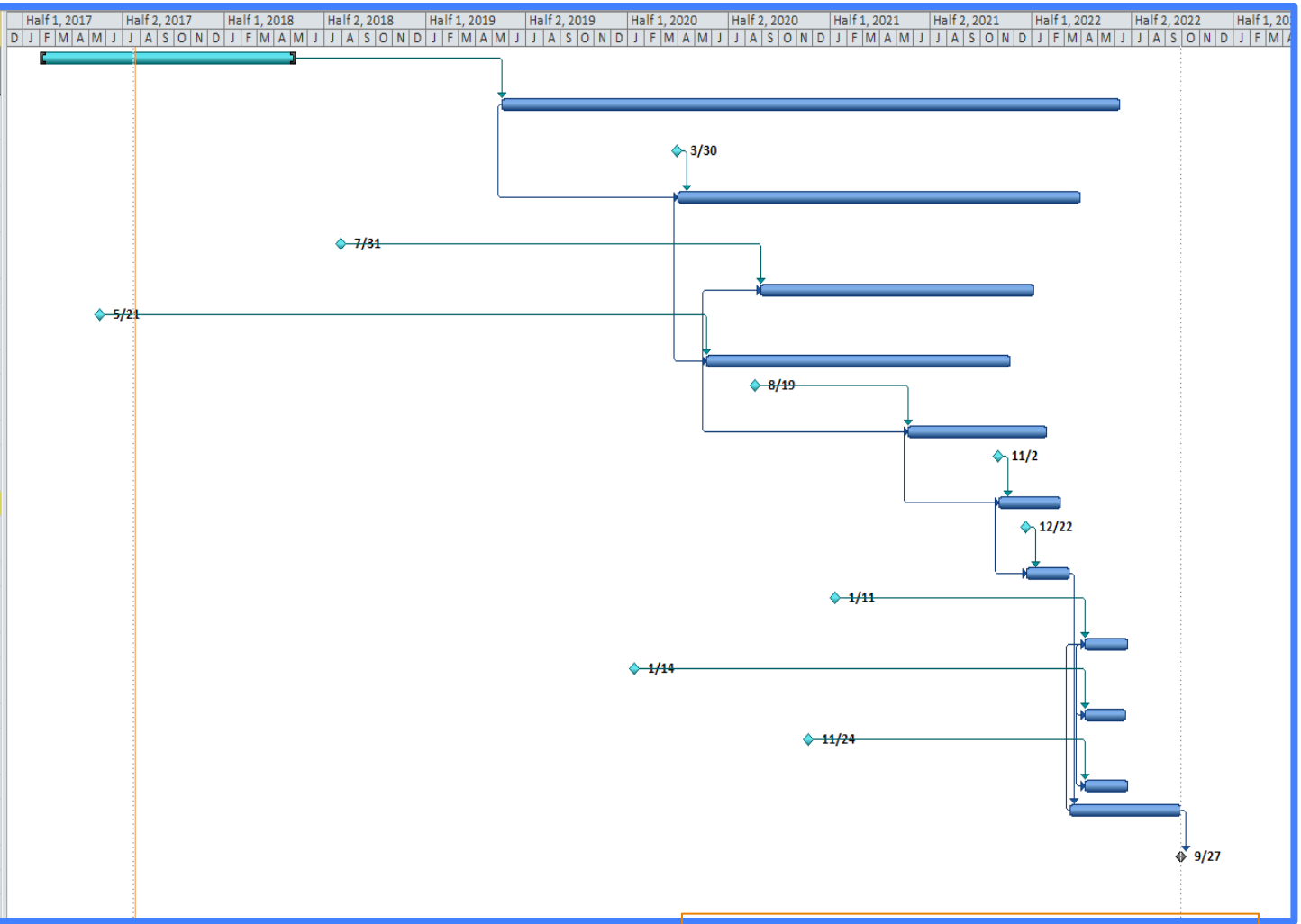
Installation and Integration

SUBSYSTEM	PERCENT OF ESTIMATES	CONTINGENCY
Engineering estimate	73	0.40
Similar Experience	27	0.25
Average contingency		0.36



Schedule

Task Name	Duration	Start
Subsystem Interface & Integration Plan	330 days	Wed 2/1/17
Infrastructure Installation	800 days	Fri 5/17/19
Ready to Assemble Cradle Carriage in AH	0 days	Mon 3/30/20
Cradle Carriage Assembly/Installation	523 days	Mon 3/30/20
Ready to Install SC Magnet	0 days	Tue 7/31/18
sPHENIX SC Installation	353 days	Fri 8/28/20
Outer Hcal Ready for Installation	0 days	Sun 5/21/17
Outer Hcal Installation	393 days	Thu 5/21/20
Inner HCal Sectors Ready for Installation	0 days	Wed 8/19/20
Inner Hcal Installation	180 days	Fri 5/21/21
EMCal Sectors Ready for Installation	0 days	Tue 11/2/21
EMCal Installation	81 days	Tue 11/2/21
TPC Ready for Installation	0 days	Wed 12/22/21
TPC Installation	56 days	Wed 12/22/21
INTT Ready for Installation	0 days	Mon 1/11/21
INTT Installation	56 days	Thu 4/7/22
MVTX Ready for Installation	0 days	Tue 1/14/20
MVTX Installation	53 days	Thu 4/7/22
Min Bias Ready for Installation	0 days	Tue 11/24/20
Min Bias Installation	56 days	Thu 4/7/22
sPHENIX Full Detector Installation	144 days	Thu 3/10/22
sPHENIX Ready for Run 1	0 days	Tue 9/27/22



Full sPHENIX Installation schedule can be found in the review document package at:

https://sites.google.com/site/sphenixdirectorsreview/

Risk Registry

	sPHENIX Risk Registry								
	Owner	WBS	Risk Name	Risk trigger (if)	Consequences (then)	Timeframe	Probability	Impact	Rank	Mitigation Plan
32	D. Lynch	1.10 Integration and Installation	Subsystem not ready for installation	Subsystem not delivered in time for scheduled installation	Delays in construction/installation of sPHENIX	Installation	Moderate: 30%	Moderate: Cost: $0, Schedule: 0-6 months	Moderate	Build in adequate schedule contingency
33	D. Lynch	1.10 Integration and Installation	Labor not available for installation	Labor not available for timely installation	Delays in construction/installation of sPHENIX	Installation	low: 10%	Moderate: Cost: 0-$20K, Schedule: 0-6 months	Low	Secure more labor support/ temporary hires
34	D. Lynch	1.10 Integration and Installation	Pole Tips delayed	Fabrication delayed	Pole tips not available when scheduled for installation:delays move to IR for following installation.	Installation	low: 10%	Moderate: Cost: $0, Schedule: 0-6 months	Low	Reliable experienced fabricator(s), adequate schedule contingency (pole tips installation near end of installation schedule)

The Registry section for Integration/Installation and other non-MIE subsystems is managed and monitored the same as for the MIE items. The Installation risk issues generally have to do with availability of labor and material in a timely fashion. These are mitigated by having a tight management structure and closely coordinated engineering for MIE and non-MIE subsystems.

Full sPHENIX Risk Registry can be found in the review document package at:

https://sites.google.com/site/sphenixdirectorsreview/

Summary

- Installation and Integration Concepts are maturing
  - Outer detectors at design stage
  - Inner detectors still conceptual
    - Timely interface information from Inner Detectors (MVTX, INTT) *(particularly for service routing)*
- Experienced personnel and a well-acquainted collaborator base
  - Experienced staff, outside experts
  - Challenge: Engineering and technical resources need to be augmented to meet requirements
- Installation schedule depends on
  - delivery of subsystems on time
  - Availability of engineering resources for procedures, planning, tooling design *(No significant technical challenges, just engineering and design resource allocation)*
- Key coordination efforts
  - Coordination with infrastructure design efforts
    - Pole tip design
    - Cradle carriage design
    - Inner detector support structures
  - Coordination with detector subsystems for commissioning during installation *(delays in subsystem delivery may disrupt installation schedule)*
  - Coordination with non-sPHENIX BNL groups *(priority issues)*
  - Coordination with non-BNL sPHENIX collaborators *(CAD software issues)*

Backup Slides

Installation L2/CAM/Key Personnel

Key Personnel:

*All have **25 + years** Analyzing, Designing, Assembling and Installing **Similar Detector subsystems** at BNL*

Donald Lynch, P.E. *Chief Engineer for sPHENIX*
Relevant Experience
Five years as sPHENIX Chief Engineer. Thirteen years as PHENIX Chief Engineer (12 data taking runs, 9 new detector SUBSYSTEM projects, numerous overhaul/upgrades of existing subsystems, numerous facility and infrastructure projects) Thirteen years as Sr. Project Engineer at BNL/NSLS 15 years Non-BNL aerospace, thermal and mechanical engineering projects

Rob Pisani, Sr. Scientific Associate for sPHENIX
Relevant Experience
25 years particle detector support experience. SSC EmCal Prototype R&D(1993 Built/test), R&D PHENIX Rich Prototype, PHENIX HBD prototype, PHENIX TEC detector, PHENIX Gas System Coordinator (multiple systems), PHENIX VTX/FVTX Cooling System, Deputy Mgr of PHENIX Removal & Repurposing.

Paul *Giannotti* *Principal Engineer and ES&H Coordinator, Electrical Engineer, Physics Department, BNL*
Relevant Experience
Designer of PHENIX Control Room indication and alarm system, emergency shutdown safety system, and electrical power distribution. Operations and ES&H support for all PHENIX runs 2000-2016.

Steve Boose, *Electronics Engineer for sPHENIX*
Relevant Experience
25 years. Software / hardware design at BNL in support of the NASA SeaWiFS, DOE Ocean Margins Program and the PHENIX experiment at RHIC. 4 years Software / hardware design and technical support for the scientific laser industry. 10 years Electronics troubleshooting and repair in high vacuum, information systems and audio.

Rich Ruggiero, *Sr. Design Engineer for sPHENIX*
Relevant Experience
2012 - Present as sPHENIX Sr. Design Engineer. Responsible for all sPHENIX integration coordination and conceptual design. 1997-Present PHENIX Design Engineer responsible for all integration and cable routing, survey/installation, work access and detector upgrades. 1986 – 1997 BNL Designer for D0 Central Calorimeter, D0 EMCal and Coarse Hadronic sectors, Oasis proposal (predecessor to PHENIX), and various NSLS, AGS and ATLAS design projects.

Carter Biggs, *Sr. Technical Associate for PHENIX and sPHENIX*
Relevant Experience
2012-Present Technical Supervisor for the PHENIX and sPHENIX projects, responsible for the construction and maintenance of the PHENIX detector subsystems and their respective upgrades. Also supervised the construction and test set-ups for the H-Cal and EM-Cal prototypes for S-PHENIX.
1993-2012 Technical Associate responsible for the set-up of the PHENIX Time Expansion Chamber factory and the completion of those 2 meter x 4 meter wire chambers. Facility Space Manager for Bldg. 1008, coordination of the techs, engineers, scientists, and trades during the RHIC runs and shutdowns.

WBS Dictionary

WBS Dictionary entries for the 2 control accounts that comprise the Installation and Integration Subsystem

Technical Scope:

WBS 1.10.1 is the Control Account for Project Management costs associated with Integration and Installation.

Work Statement:

This Control Account encompasses the efforts of the Integration and Installation level 2 manager to manage this subsystem in accordance with the BNL and DOE requirements, including collecting and analyzing management performance data for this subsystem, reporting the data as appropriate and generally assuring that this subsystem meets cost and schedule estimates, and if the subsystem management performance strays from the baseline, implementing appropriate actions to restore performance to the baseline."

Technical Scope:

WBS 1.10.2 is the Control Account for all scientific, engineering and technical staff efforts to plan, execute and supervise all aspects of the assembly, integration and installation of the sPHENIX infrastructure components (defined by WBS 1.9), completed and tested detector subsystem modules and electronics for the sPHENIX MIE (defined by WBS 1.2 though 1.7), sPHENIX superconducting solenoid magnet (defined by WBS 1.8) and parallel detector projects to be installed in sPHENIX (defined by WBS 1.11 and 1.12).

Work Statement:

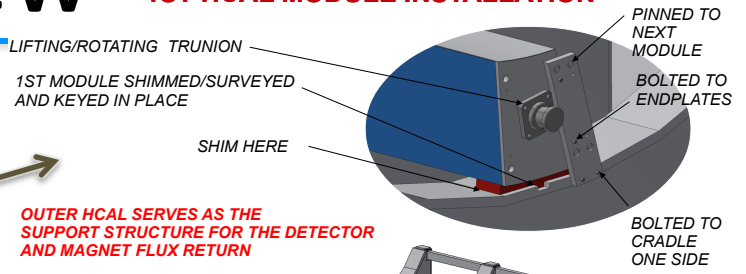
This Control Account encompasses the planning for and all of the actual installation and commissioning of these components will take place at the sPHENIX experiment complex at building 1008. There are 12 work packages included in this control account. Each work package has its own separate Basis of Estimate (BoE) document elsewhere in this workbook. These documents can be accessed from the Navigation page in this workbook."

*WBS dictionary entries for installation work packages can be found in **here***

Installation Overview

2

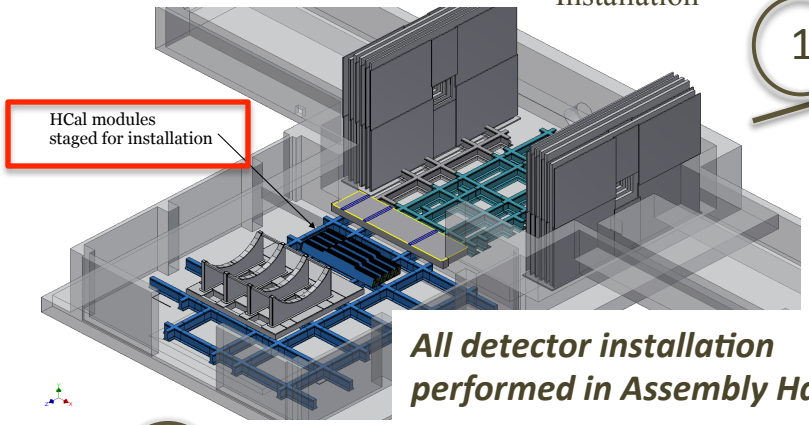
1ST HCAL MODULE INSTALLATION



OUTER HCAL SERVES AS THE SUPPORT STRUCTURE FOR THE DETECTOR AND MAGNET FLUX RETURN

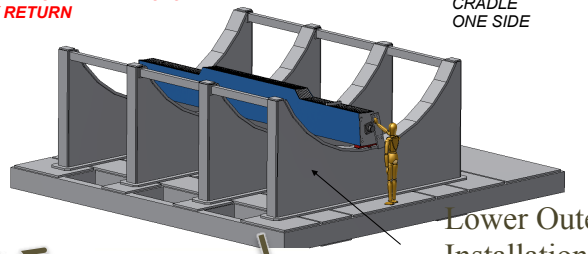
Base and Cradle Installation

1



Magnet Installation

4

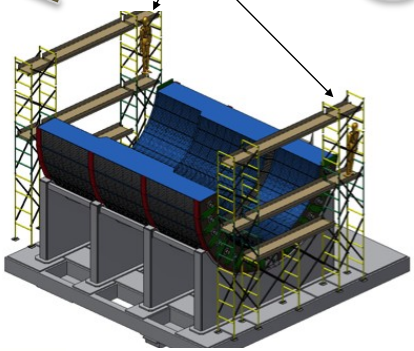


All detector installation performed in Assembly Hall

Lower Outer HCal Installation

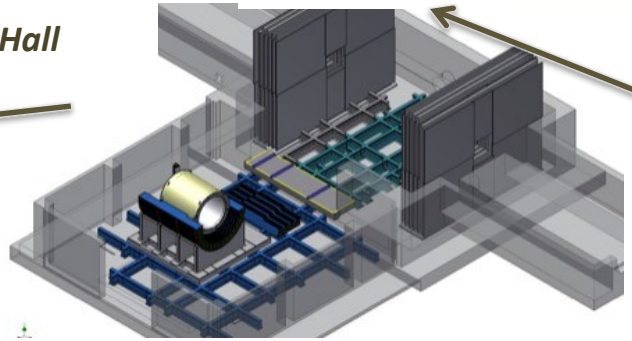
ACCESS SCAFFOLDING

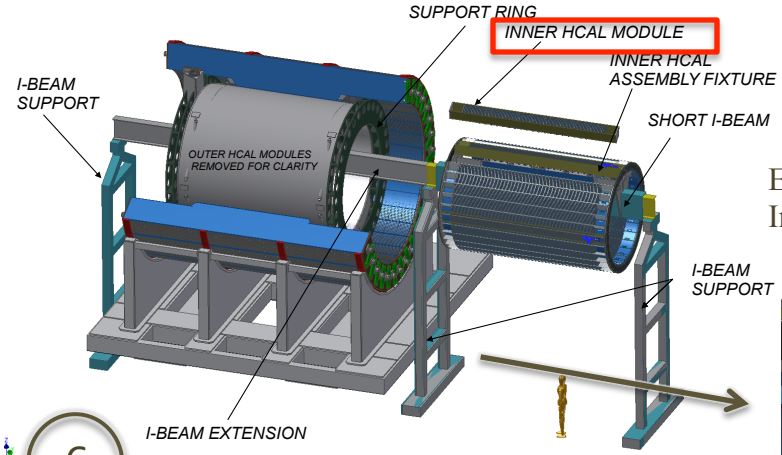
3



5

Upper Outer HCal Installation



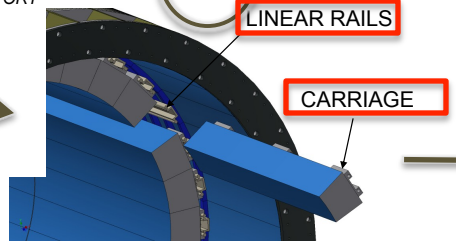


6

Inner HCal Installation

EMCal Installation

7



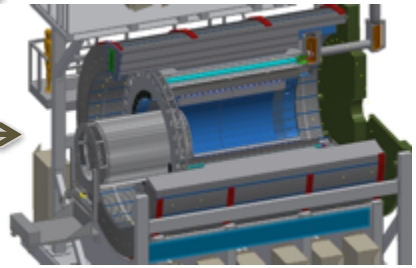
(*Next Slide*)

Installation Overview

8

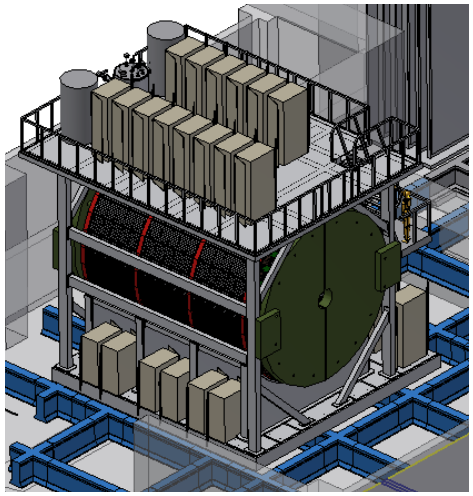
TPC Installation

(*Previous Slide*)



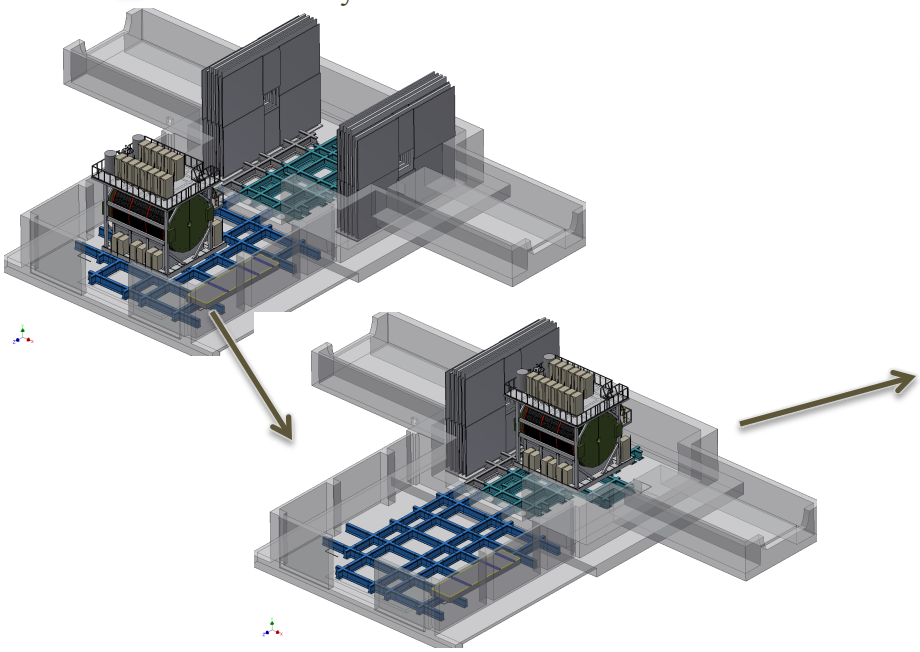
9

Complete Cradle Carriage Assembly (End cap/pole tips, platforms and access, racks, etc.)



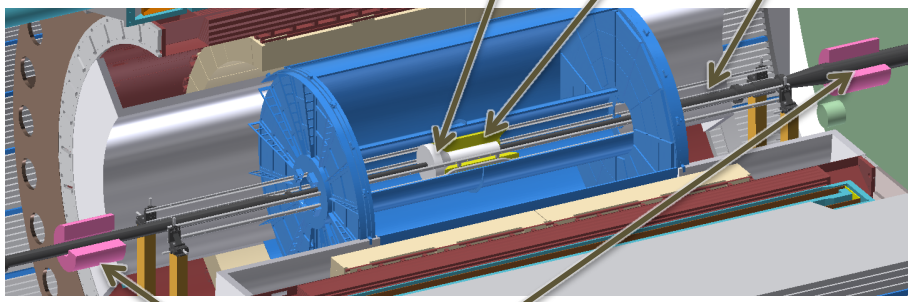
10

Move sPHENIX Assembly to IR



11

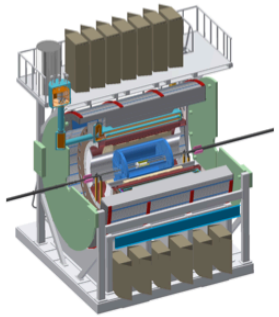
Install beampipe, INTT, MVTX and MinBias detectors and their supports and services



Installation Interfaces

Interface Control documents(ICD's) define and quantify the **interfaces between any 2 subsystems**. Interfaces include mechanical, electrical, optical, cooling, gas media, etc. For the Installation and Integration effort there are **10 documents** currently conceived. For purposes of the installation efforts, these generally refer to interfaces between the subsystems components and the tooling, fixtures, procedures and equipment required to accomplish the installation and alignment of these components.

1.1 Project Management	1.2 TPC	1.3 EMCal	1.4 HCal	1.5 Calorimeter Electronics	1.6 DAQ/ Trigger	1.7 Min Bias	1.8 SC Magnet	1.9 Infrastructure	1.10 Integration & Installation	1.11 INTT	1.12 MVTX	
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.1 Project Management
	N/A	N/A	N/A	N/A	sP.SE-ICD-004	N/A	N/A	sP.SE-ICD-00	sP.SE-ICD-016	N/A	N/A	1.2 TPC
		N/A	sP.SE-ICD-001	sP.SE-ICD-002	sP.SE-ICD-005	N/A	N/A	sP.SE-ICD-01	sP.SE-ICD-017	N/A	N/A	1.3 EMCal
			N/A	sP.SE-ICD-003	sP.SE-ICD-006	N/A	N/A	sP.SE-ICD-01	sP.SE-ICD-018	N/A	N/A	1.4 HCal
				N/A	sP.SE-ICD-007	N/A	N/A	sP.SE-ICD-01	sP.SE-ICD-019	N/A	N/A	1.5 Calorimeter Electronics
					N/A	sP.SE-ICD-008	N/A	sP.SE-ICD-01	sP.SE-ICD-020	.SE-ICD-024	sP.SE-ICD-027	1.6 DAQ/ Trigger
						N/A	N/A	sP.SE-ICD-01	sP.SE-ICD-021	N/A	N/A	1.7 Min Bias
							N/A	sP.SE-ICD-01	sP.SE-ICD-022	N/A	N/A	1.8 SC Magnet
								N/A	sP.SE-ICD-023	.SE-ICD-025	sP.SE-ICD-0162	1.9 Infrastructure
									N/A	sP.SE-ICD-026	sP.SE-ICD-029	1.10 Integration & Installation
										N/A	sP.SE-ICD-030	1.11 INTT
											N/A	1.12 MVTX



WBS	sPHENIX MIE Project Elements
1.1	Project Management
1.2	Time Projection Chamber
1.3	Electromagnetic Calorimeter
1.4	Hadron Calorimeter
1.5	Calorimeter Electronics
1.6	DAQ-Trigger
1.7	Minimum Bias Trigger Detector

WBS	Infrastructure & Facility Upgrade
1.8	SC-Magnet
1.10	Installation-Integration

WBS	Parallel Activities
1.11	Intermediate Silicon Strip Tracker
1.12	Monolithic Active Pixel Sensors

The mechanical mounting, electrical, optical, cooling and gas connections that are made between **adjacent detector subsystems** and between detector subsystems and infrastructure/structural support components are defined in the **ICD's that are shared by each pairing of those subsystems**.