sPHENIX MIE Project Overview

TPC	Project Director	Last CD Achieved	% Complete	CPI	SPI
$27.0M	Edward O'Brien	PD-2/3	75.1% BCWP/BAC @ 5/31/2021	1.02	0.83

Scope

- Detector systems produced, tested and ready for installation: Time Projection Chamber w/ electronics, Electromagnetic Calorimeter w/ electronics, Hadronic Calorimeter w/ electronics, DAQ/Trigger, Minimum Bias Detector, Project Management

Not in scope

- SC-Magnet, Bldg/Det Infrastructure, Installation and System Commissioning

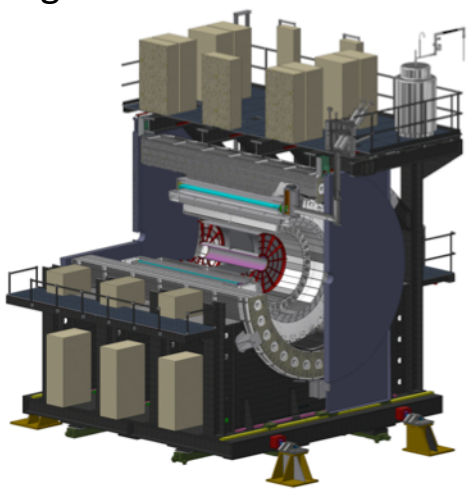
Schedule

Costed and Committed= 90.8%

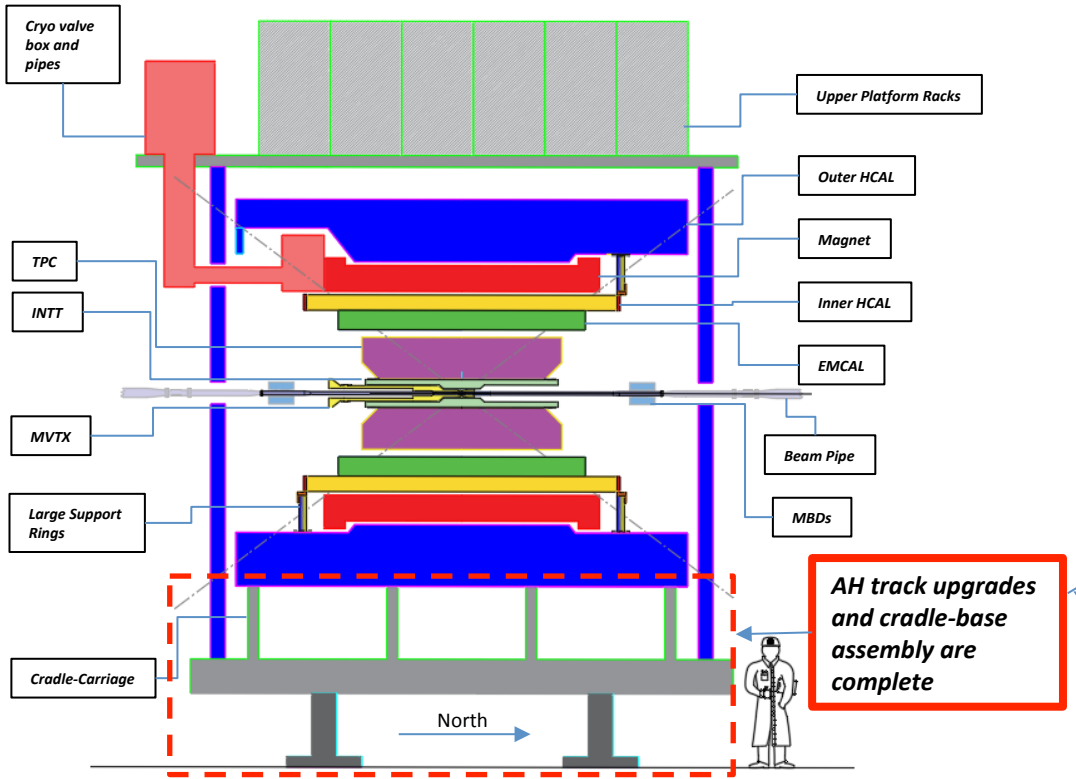
- CD-0 received Sept 2016
- CD-1/3A received Aug 2018
- PD-2/3 received Sept 2019
- **Early completion end Jan 2022 (10.75 months float to PD-4)**
- PD-4 Dec 2022

Cost

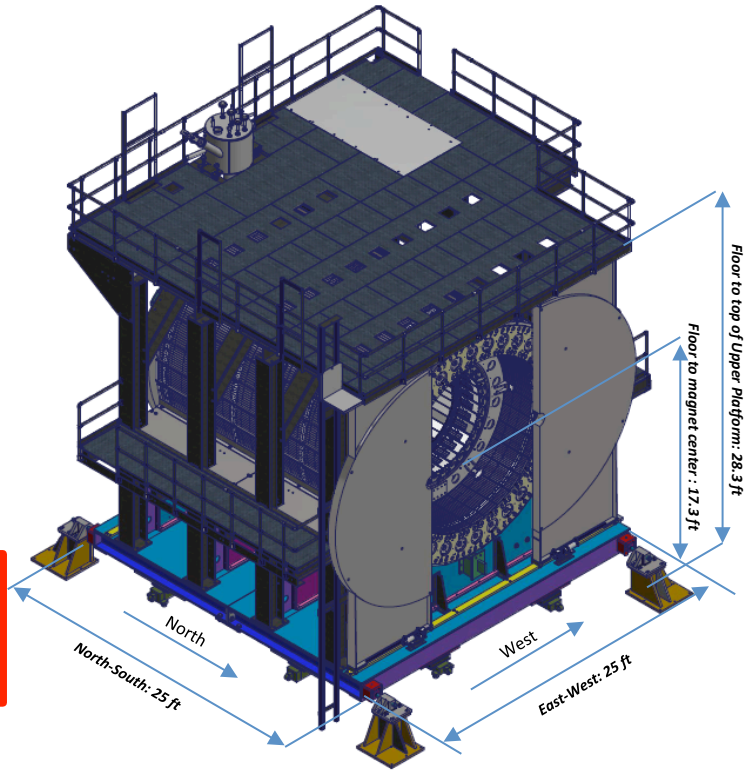
- **$27.0M AY TPC 34.6% contingency on an ETC of $6.2M**



sPHENIX Elevation View and 3-D Model



This is a simplified 2D model of sPHENIX highlighting the nested detector structures and magnet return steel construction.

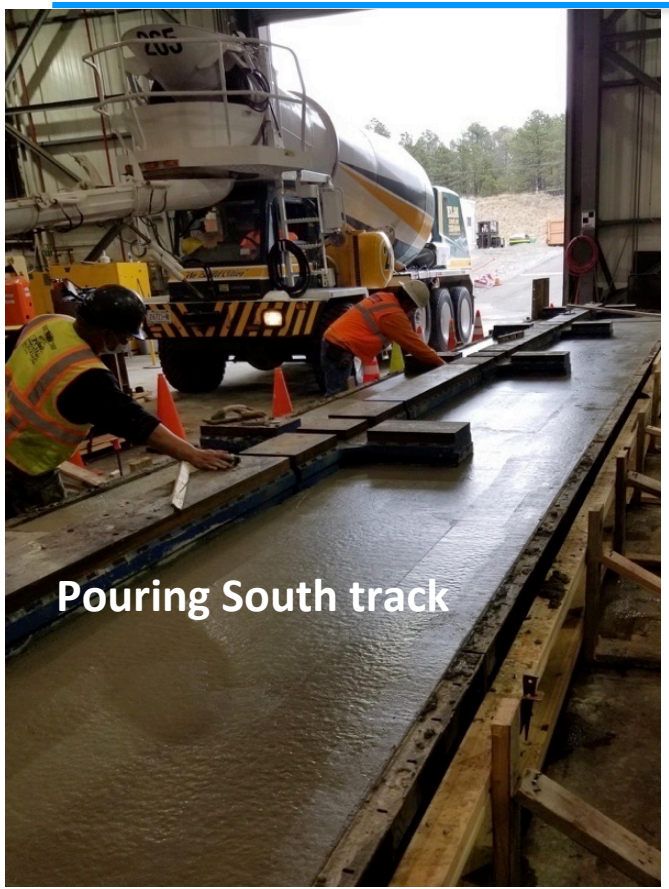


sPHENIX looking at the north side with pole tip doors open and EMCAL installed. This is the condition when sPHENIX is moved from the 1008 AH to the IR. sPHENIX will weigh ~880 tons when rolled into IR and 900 tons when complete.

Available Resources & External Dependencies

- BNL has granted the sPHENIX MIE an **Extraordinary Project Rate** (Reduced Overhead)
- Reuse of **>$20M of existing infrastructure and equipment** from the PHENIX experiment including use of the **Building 1008 (PHENIX) complex**
- BNL-funded **Infrastructure and Facility Upgrade ($33.4M AY) to 1008 complex** including bringing cryogenics for the SC-Magnet into the sPHENIX IR, upgrading safety, power, environmental controls, cooling systems, providing steel flux return for the magnet.
- **BNL contributed labor from RHIC Ops ($25M AY)** (80% the PHENIX group in Phys Dept in addition to CAD, BNL Instrumentation, NSLSII and Magnet division)
- Former **BaBar SC-magnet received from SLAC spring 2015**. Tested to 105% of full current at BNL.
- Collaborator contributed labor (subsystem assembly and testing, QA, calibration, commissioning)
- **Si strip detector (INTT)** primary funding from RIKEN Lab –Japan with additional US and international contributions.
- Extended (in eta) EMCal coverage to (-1.1< eta < 1.1) from international sources.
- BNL-funded capital project for instrumentation of an **Inner HCal ($1.6M)**
- BNL-funded capital project for an **Si pixel detector (MVTX) ($4.8M)**

Track Reinforcement in 1008 Assembly Hall 5/14/21



1st sPHENIX Component Installed in sPHENIX Hall, 5/27/21

Base Installation Complete 6/1/21

Carriage/Cradle Assembled 6/11/21

- Surveyors, engineers and techs are leveling and squaring the carriage/cradle frame prior to installation of first subsystem component, the 1st Outer HCal sector, week of 6/21.

sPHENIX Calendar

• SPHENIX Collaboration meeting	Jun 17-18
• ESRC TPC Review	Jun 21
• Installation of 1st sPHENIX OHCal sector in RHIC Hall	wk of Jun 21
• IHCal Installation PRR	Jun 22
• RHIC PAC	Jun 22-23
• **Annual sPHENIX MIE Review**	**Jul 14-15**
• ESRC Calorimeters Review	Jul 26
• ESRC IHCal/EMCal/TPC/MVTX/INTT Installation Review	Sep 27
• ESRC MBD and beam pipe Review	Oct 18
• ESRC MVTX/INTT Review	Nov 15
• sPHENIX MIE Early completion date	Jan 31, 2022
• sPHENIX Ready for Operations	Oct 12, 2022
• Start of RHIC 2023 Run	Feb 1, 2023

Annual Review Committee July 14-15

Review Committee Chair
*Ken Read, ORNL

Subcommittee 1—Calorimeters and Tracking
* John Parsons, Columbia
Ken Read, ONRL
Subcommittee 2—Data Acquisition, Triggers, and Electronics
*Myron Campbell, U of Michigan
Rainer Bartoldus, SLAC
Vivian O'Dell, Univ of Wisconsin
Subcommittee 3—Environment, Safety and Health
*Bill Rainey
Subcommittee 4— Cost and Schedule
Elmie People-Evans, ANL
Julia Chaffin, LLNL
Subcommittee 5— Project Management
Ron Ray, FNAL
*Patty McBride, FNAL

DOE invitees
James Sowinski
Paul Mantica
Kenneth Hicks
Elizabeth Bartosz
Robert Caradonna
Ivan Graff
Jehanne Gillo

sPHENIX Status

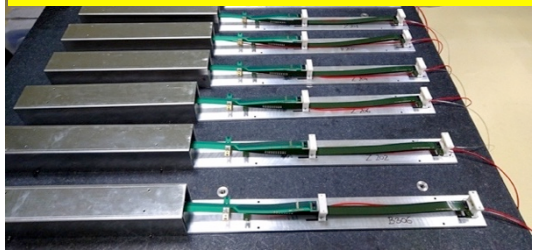
- **The OHCAL Sectors are complete.** Electronic burn in tests continue until sectors ready to install starting in June
- **EMCal blocks 65% complete at UIUC**. Fab on all but final 6% of blocks has started. **EMCal Sectors 42% complete at BNL. Testing and calibration ongoing.**
- **TPC Fee board** ready for fab. PCB fab started. **Testing of SAMPA v5 ASIC complete at Lund**. **6300 good chips** shipped to and received at BNL (5000 chips required)
- **GEM Module framing for TPC >60% complete at** WSU, WIS, Vanderbilt, Temple
- Major computer orders, Buffer boxes, EBDCs, starting to arrive in 1008
- **TPC Fee slice test continuing at BNL.**
- **All R1, R2, R3 TPC pad planes at SBU**
- **84/84 MVTX "Gold+ Silver " staves** complete at CERN.
- **> 30% production INTT ladders** complete

TPC Wagon Wheel w/ R1, R2, R3 @ SBU

EMCal sector testing @ BNL

INTT ladders/HDIs @ BNL

MVTX Staves @CERN



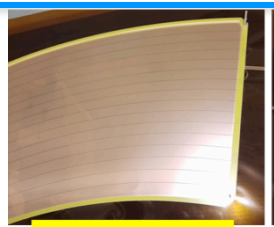
1008 Infrastructure and Facility Upgrade Status

- **sPHENIX Installation in 1008 has begun**
- **XY Carriage tables, Carriage Hydraulics installed**
- **Magnet flux return Pole tip/end cap** in production
- **sPHENIX Beam Pipe** at vendor for modification.
- **Large Support Rings** in production
- Platform, EMCal installation fixture awarded
- **Work on IR track reinforcement starts mid-July**
- Engineering design work continues at a fast pace

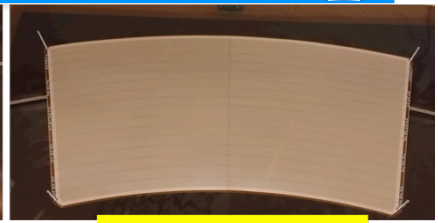
- **LHe cryo components to be completed by this summer. LN2 piping,** in production or at BNL.
- Meetings held with **CERN group** that will be performing the **magnet mapping in 2022**.
- **The I&F Early Completion date has been unchanged throughout the pandemic.**
- **3.5 months of float from RHIC Run 2023 start and I&F early completion.**
- **Observing significant cost increases on raw materials.**

TPC GEM Production Rate and Yield

GEM production going very well. Avg yield > 90%
Framing 100 good GEMs ea type +30% spares



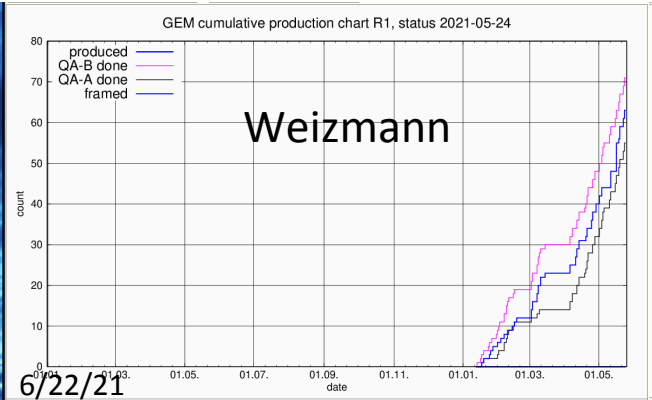
R2 GEM w/ Frame

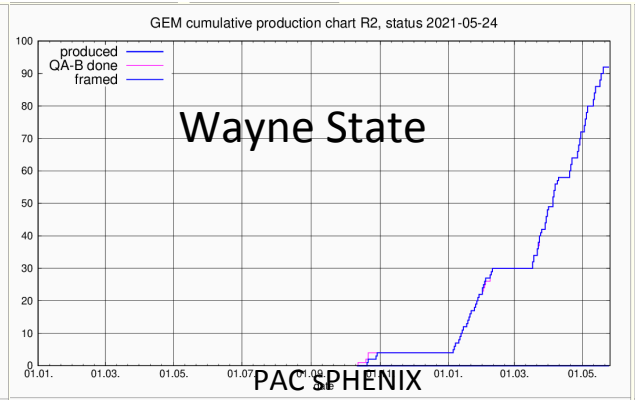


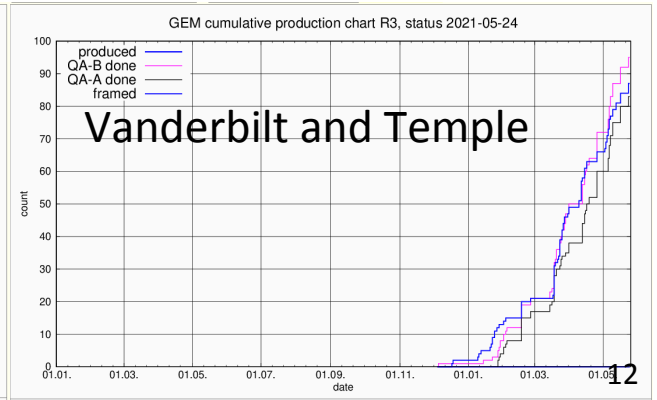
R3 GEM pinned to QA Jig

2021-06-07	R1					R2					R3				
flavor	G1	G2	G3	G4	sum	G1	G2	G3	G4	sum	(V+T)G1	(V+T)G2	(V+T)G3	(V+T)G4	sum
produced	36	30	33	38	137	35	30	29	35	129	35	35	32	30	132
QA-B done	21	24	22	16	83	25	25	27	18	95	23	24	22	21	90
QA-B passed	21	24	22	11	78	24	24	25	16	89	21	23	22	21	87
QA-B yield	1.00	1.00	1.00	0.69	0.940	0.96	0.96	0.93	0.89	0.937	0.91	0.96	1.00	1.00	0.967
framed, ok	21	23	20	11	75	25	25	27	18	95	21	20	22	21	84
framing fraction of prod.	0.58	0.77	0.61	0.29	0.547	0.71	0.83	0.93	0.51	0.736	0.60	0.57	0.69	0.70	0.636

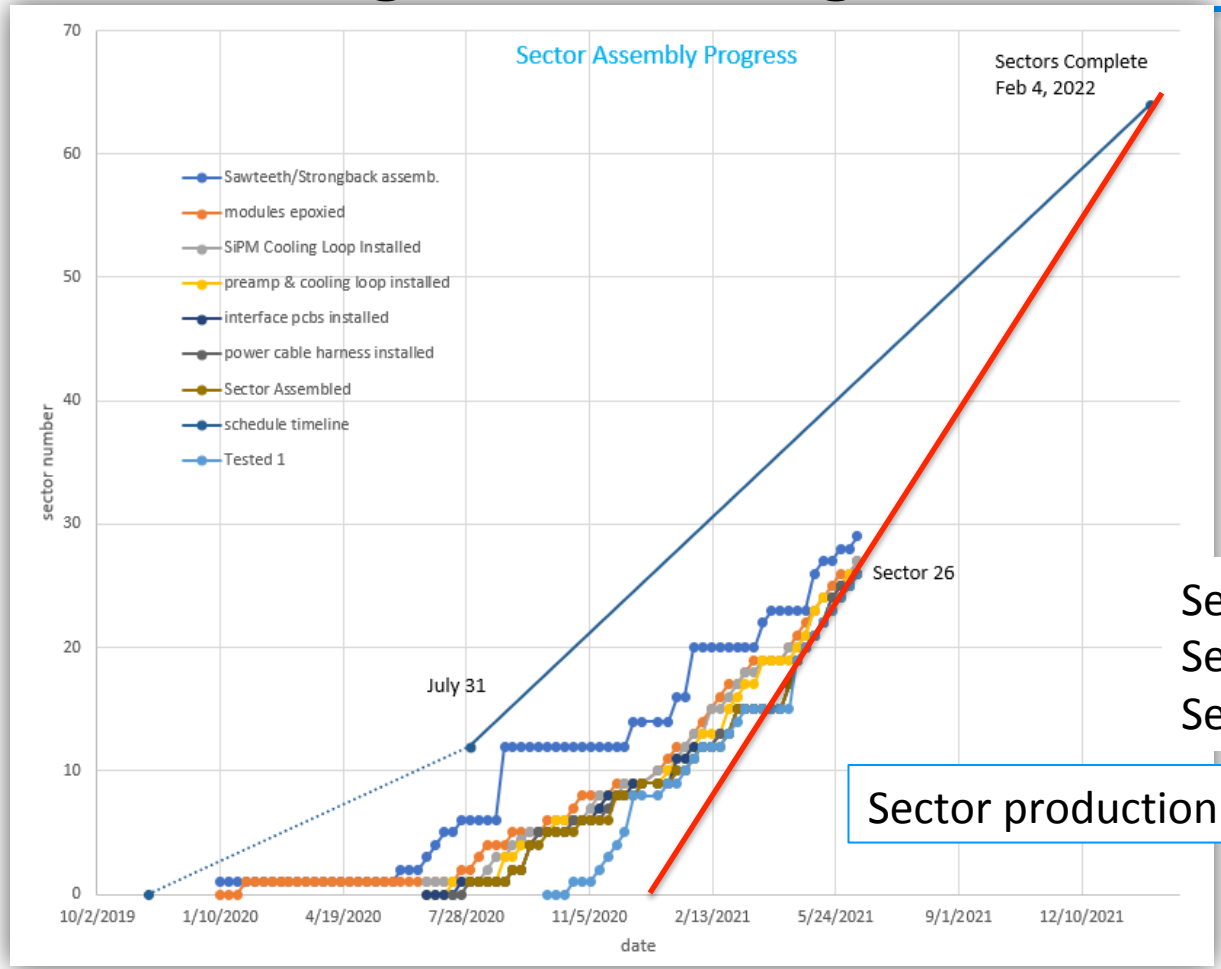
R1 GEM







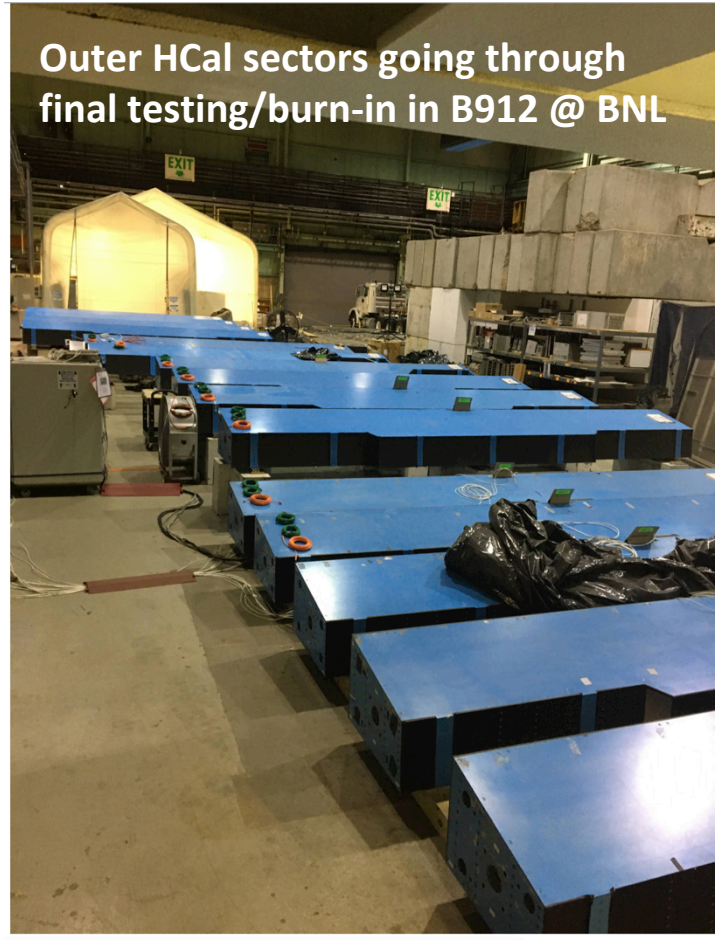
EMCal Progress Tracking – Sector Assembly



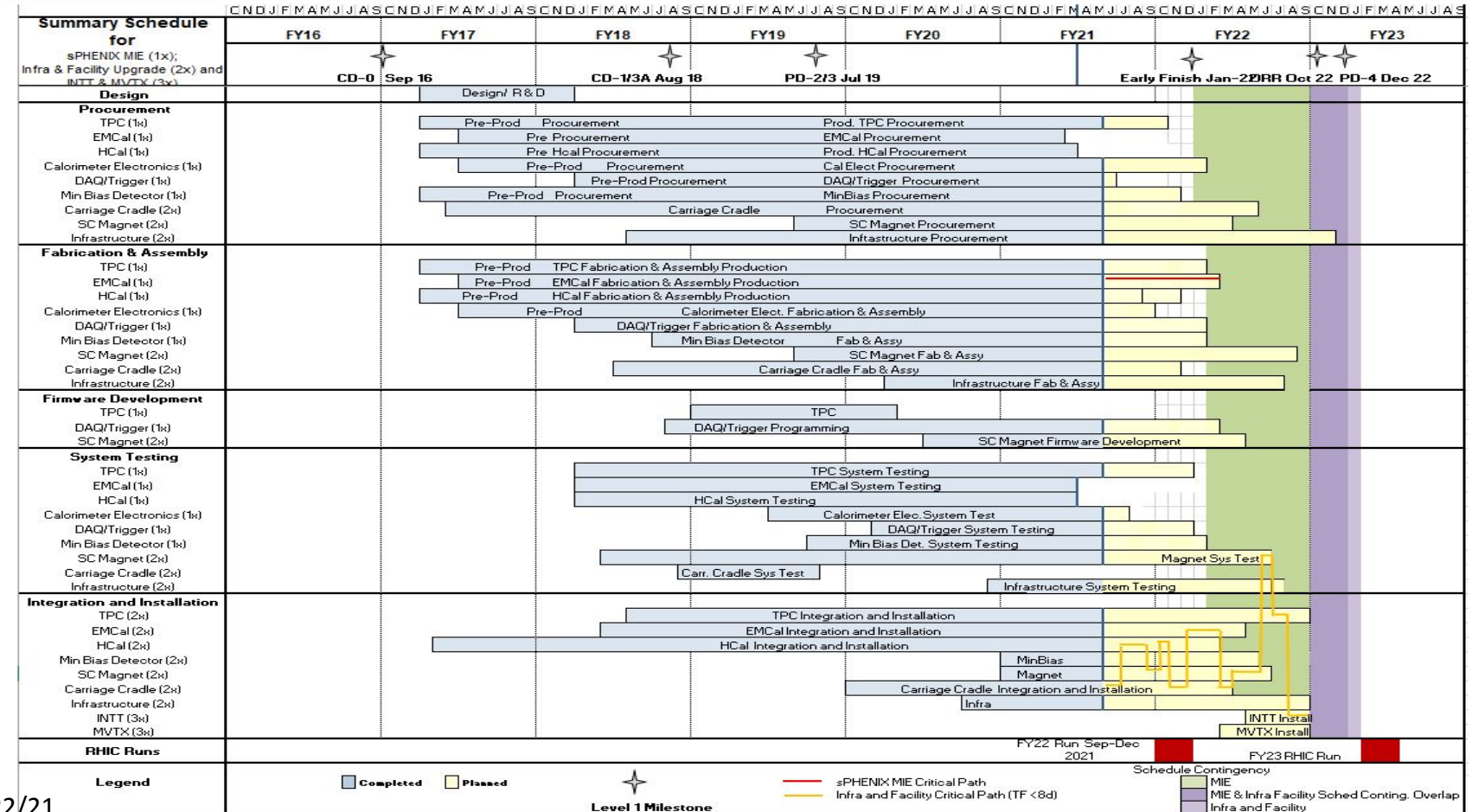
Sectors 1-27 complete
Sectors 28-29 being assembled
Sector 30 assembly starts next week

Sector production slope consistent with P6

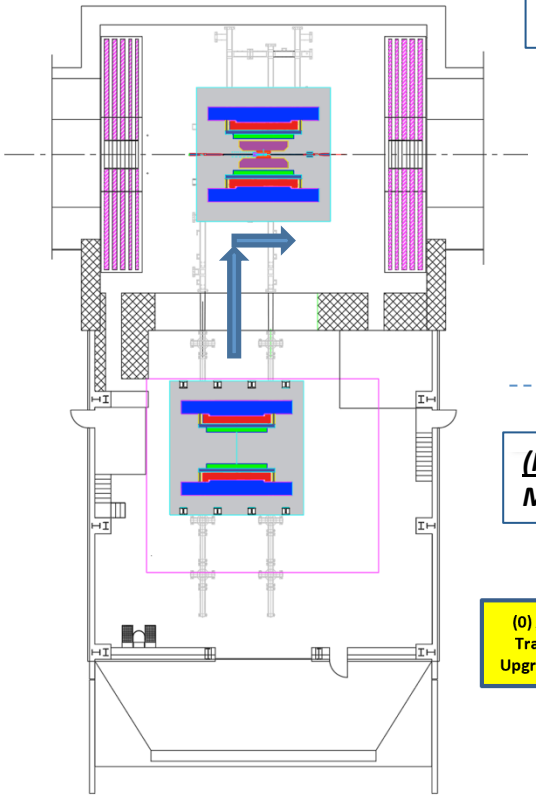
HCal Progress



Summary Schedule – sPHENIX MIE and 1008 Infra and Facility Upgrade



sPHENIX Assembly Sequence



(II) IR Hall Work
April-22' to Oct-22'

(19C) Other 1008 complex Infrastructure: Power, HVAC, Gas House, Chillers

(19B) On-Carriage Structures and Infrastructure: Stairs, Seismic Supports, Power, Cabling, Water and Gas Piping

(19A) On-Carriage Racks, DAC, Counting House and Control Room Upgrades

(10B) IR Cryo Upgrades

(11) Move to IR

(12) Magnet Connect

(13) Magnet Mapping

(14) TPC

(15) Beam Pipe

(16) INTT

(17) MVTX

(18) MBD

(20) ORR

Build north and south work platforms

(I) Assembly Hall Work
May-21' to April-22'

(6A) iHCAL barrel fab

(6B) iHCAL install structures

(6C) iHCAL insert

(7) EMCAL

(0) *AH* Track Upgrades

(1) Cradle-Base

(2) oHCAL 1-13

(3) Magnet Mount

(4) Large Rings

(5) oHCAL 14-32

(8) Upper Platform

(9A) Pole Tip Doors

(9B) Magnet Valve Box

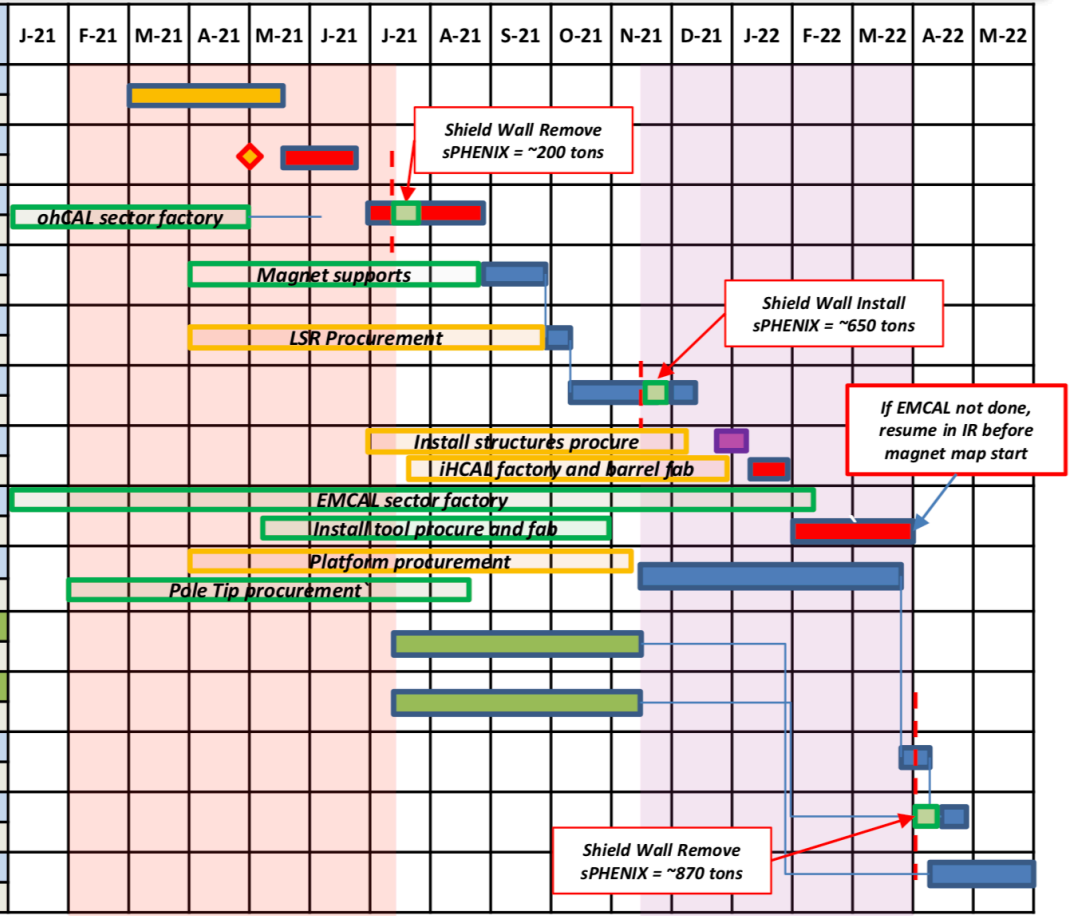
(10A) IR Track Upgrades

(11) Move to IR

oHCAL work will continue through the end of the 2021 calendar year

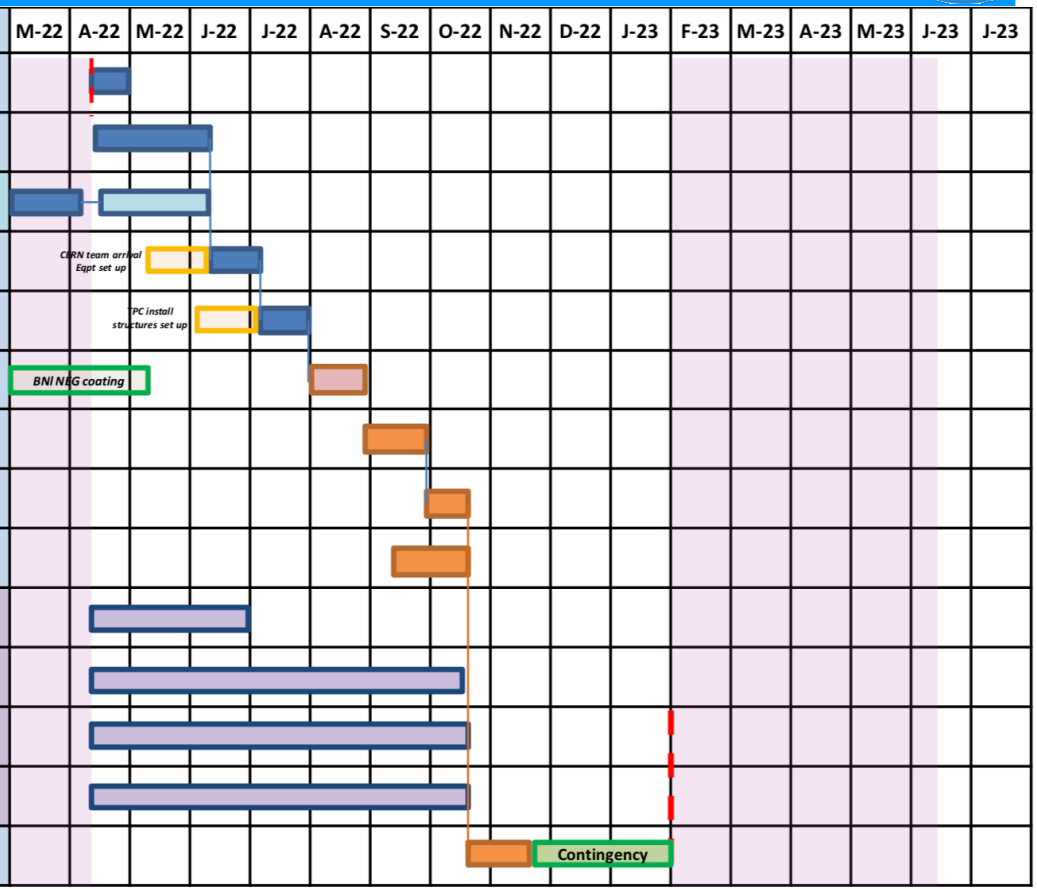
1008 Assembly Hall Installation Schedule

Sequential Build Steps	Locate	Start	End
AH Track Upgrades *(started 3/1)*	AH	3/1/21 3/1/21	5/3/21 5/14/21
Cradle-Base	AH	5/4/21 5/25/21	6/2/21
Outer HCAL 1-13	AH	6/4/21	8/25/21
Secure Magnet in oHCAL, Tests	AH	8/26/21	9/29/21
Large Support Rings	AH	9/30/21	10/6/21
Outer HCAL 14-32	AH	10/7/21	12/10/21
Inner HCAL Barrel Install	AH	1/10/22	1/28/22
EMCAL	AH	2/7/22	3/21/22
Carriage, Platforms, Cable Tray and Pipe Supports, Pole Tips	AH	11/15/21	3/28/22
LN2/Helium Line Infrastructure	IR	7/15/21	11/15/21
IR Track Upgrades	IR	7/15/21	11/15/21
Magnet Valve Assembly	AH	3/28/22	4/5/22
Move sPHENIX to IR	AH to IR	4/6/22	4/20/22
Magnet Cryo and Electric Connect	IR	4/6/21	6/13/21



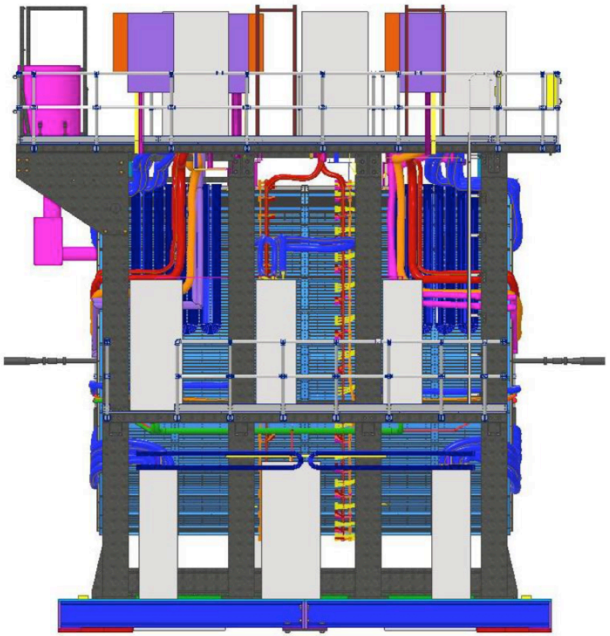
1008 Interaction Region Installation Schedule

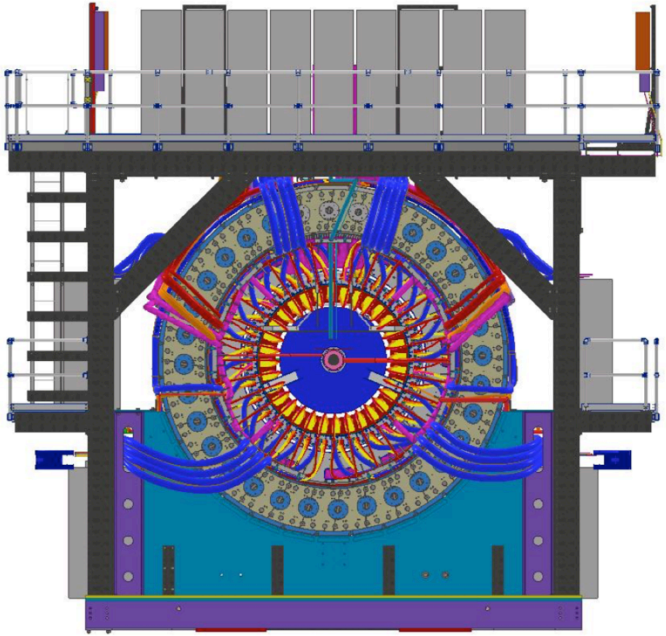
Sequential Build Steps	Locate	Start	End
Move sPHENIX to IR	AH to IR	4/6/22	4/20/22
Magnet Cryo and Electric Connect	IR	4/6/22	6/13/22
Complete EMCAL (if needed, not in P6)		4/6/22	6/13/22
Magnet Mapping	IR	6/14/22	7/6/22
TPC	IR	7/11/22	7/22/22
Platforms, Beam Pipe Install and Bake	IR	8/1/22	8/30/22
INTT	*IR*	*8/31/22*	*9/22/22*
MVTX	*IR*	*9/23/22*	*10/18/22*
MBD And *Final Beam Pipe Supports*	IR	9/8/22	10/18/22
Carriage Stairs and Seismic Supports	*IR*	*4/20/22*	*6/26/22*
Racks	*IR*	*4/20/22*	*10/18/22*
Carriage Infrastructure (continued)	*IR*	*4/20/22*	*10/18/22*
Other 1008 Infrastructure	*IR*	*4/20/22*	*10/18/22*
ORR (Early Finish)	IR	10/19/22	11/21/22

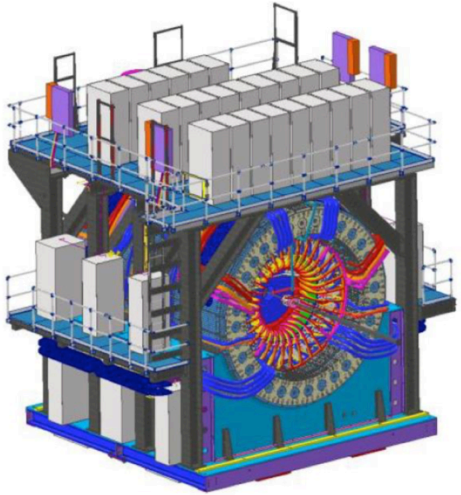


INTT Support Structure After TPC, Before Beam Pipe

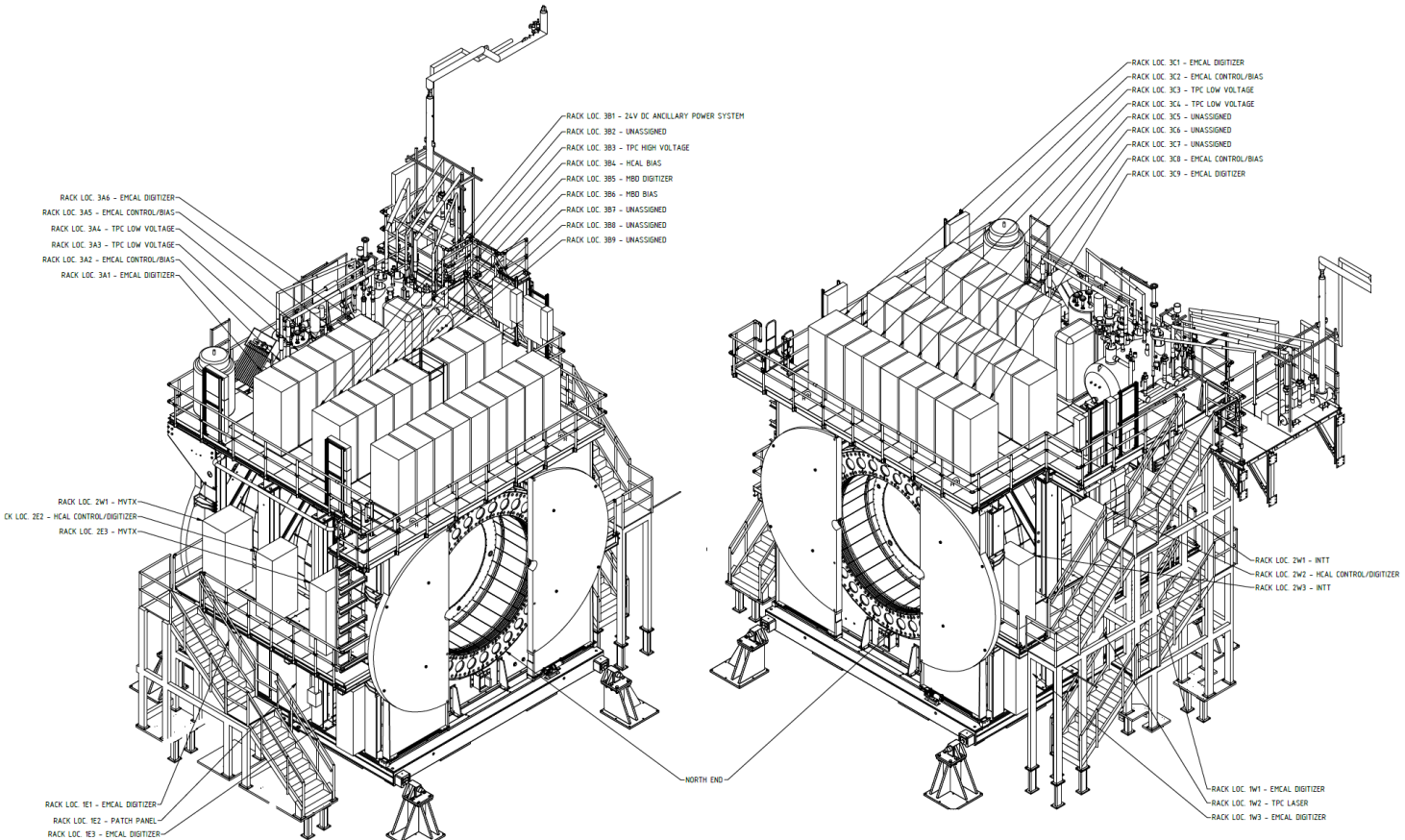
On Carriage Infrastructure







sPHENIX rack assignments



sPHENIX Commissioning Task Force

- In March 2021, the spokespersons approached John and Caroline and we agreed to co-chair a new body called commissioning task force. The spokespersons and we approached several collaborators and asked them to join the commTF.
- We found it useful to have as little overlap as possible with the group of L2 managers.
- Some but not all persons in the commTF represent a specific subsystem.

Name	Institution	Represents
John Haggerty	BNL	co-chair
Caroline Riedl	UIUC	co-chair
Walter Sondheim	Los Alamos	(MVTX)
Ming Liu	Los Alamos	(MVTX)
Klaus Dehmelt	Stony Brook	TPC
Jin Huang	BNL	
Takao Sakaguchi	BNL	
Rachid Nouicer	BNL	INTT
Stefan Bathe	CUNY	HCal
Tim Rinn	UIUC	EMCal
Martin Purschke	BNL	DAQ software & Trigger
Chris Pinkenburg	BNL	offline
Russ Feder	BNL	integration
Steve Boose	BNL	integration
Joel Vasquez	BNL	integration

Goals & Definition of Commissioning Task Force

- Transition from the MIE project to the collaboration
- Commissioning planning has to start well before the first collisions due to the aggressive installation schedule.

construction of MIE and non-MIE components → assembly hall now → interaction region early 2022 → first beam early 2023 → physics data ???

L2 / L3 managers → … → collaboration with subsystem experts →

Commissioning stages and components

Commissioning stages

1. Pre-installation commissioning and testing
2. Installation commissioning
3. Post-installation commissioning
4. Magnet commissioning
5. DAQ and Electronics Commissioning and Installation
6. Full detector commissioning (essentially DAQ and computing commissioning)
7. Trigger commissioning
8. Cosmic ray running
9. Beam operation

Commissioning components

- TPC
- EMCAL
- OHCAL
- IHCAL
- MBD
- Computing
- Trigger/Timing
- DAQ
- Control and Monitoring (AC/LV/HV/safety)
- Magnet and cryo
- Non-MIE
  - **INTT**
  - **MVTX**

Pre-installation commissioning and testing

- Testing of components prior to installation in detector
- May or may not involve connection to complete services (power, cooling, DAQ, trigger), but should as much as feasible
- This stage is largely covered by the detector MIE project but requires a clean (and quick!) segue to the next stage
- Mostly not in 1008 (except for DAQ/Trigger/Computing/ Control/Monitoring)
- Collaborators at this stage develop the experience and expertise needed for all subsequent stages

SC-Magnet commissioning

- Largely decoupled from other commissioning steps, but many implications and requirements for safe operation
- Can happen only in IR
- There will be a (hopefully brief) period of time which will impede any other work on the detector
  - **Initially, IR will be locked out when the magnet is ramped**
  - **Work on the carriage and detector will be restricted during the actual mapping campaign**
- Magnet mapping
- April-July 2022

DAQ and Electronics Commissioning and Installation

- Development of DAQ software, installation of DAQ computing, and integration with FEE should take place in stages of progressively increasing complexity
- Unfortunately, full system tests before installation in the detector will not be possible, but we should test as large a chunk as possible
- Because of the size and power requirements, this will be in the 1008 Rack Room
- The testing may appear to be somewhat front-loaded, but that's by design, to allow sufficient float to recover from problems which require substantial software development

Detector commissioning/chain/slice tests I

1. Single FEE tests
   - **1 TPC FEE + 1 FELIX + GL1GTM NIM-to-optical**
   - **1 XMIT group + 1 DCM/JSEB + GL1GTM NIM-to-optical**
   - **Test multievent buffering as GL1GTM firmware available; random triggers; data integrity**
   - **Performance measurements (livetime vs rate)**
2. Develop and implement zero suppression for CAL and TPC
   - **Desirable to have zero suppressed formats early in order to work with data as we plan to take it**
3. Development of data logger (SDL—sPHENIX Data Logger)
   - **100% software development (up to a point)**
   - **Performance measurement—requires network switch + high performance Buffer Box**
   - **Log data from Single FEE tests via network to data logger**
4. Joint TPC/CAL test
   - **1 TPC FEE + 1 XMIT group + GL1GTM + SDL**
   - **Test of trigger synchronization with dissimilar systems**
5. Two FEE tests
   - **2 TPC FEE + 1 FELIX + GL1GTM**
   - **2 XMIT group + 1 DCM/JSEB + GL1GTM**
   - **Tests of synchronization between FEE**
   - **Standalone event recording followed by SDL**

Detector commissioning/chain/slice tests II

6. CAL Slice test
   - **A full rack of digitizers is 16 fibers == 2 DCM's**
   - **Start with a half-rack, take data with all 8 ports of DCM**
     - **Measure livetime/rate for random triggers; assess data integrity**
   - **Expand to full rack, 2 DCM groups, 2 JEB machines**
   - **Connect to SDL**
   - **By this time, it should be possible to use sPHENIX grade zero suppression**
7. TPC Slice Test
   - **A full sector of TPC FEE (26)**
   - **Test with 1 FELIX to start, then break down into 2**
   - **SDL**
8. CAL + TPC Slice Test
   - **Combine the above tests with SDL**
   - **At this point, the DAQ could be said to be "working"**
   - **Measure performance for random triggers**
   - **Milestone Review**
   - **Note that this step must be complete by April 2022 in order to support the installation schedule**

Major application developments

- Servers
  1. **EBDC server**
     - **FELIX configurator**
  2. **SEB server**
     - **DCM2/JSEB2 configurator**
  3. **Data Logger (SDL)**
     - **Stream configurator**
  4. **Trigger/Timing server**
     - **Trigger configuration**
     - **Timing configuration**
  5. **Calorimeter FEE configurator/monitor**
  6. **TPC FEE configurator/monitor**
  7. **INTT configurator (INTT Consortium)**
  8. **MVTX configurator (MVTX Consortium)**
  9. **OPC device control/monitoring**

- Clients
  - **"run control"**
  - **GUI's**
    - **"run control"**
    - **Others convenient tools (timing, trigger, Cal FEE, TPC FEE,…)**
    - **OPC controls and monitoring**
- Offline
  - **Offline event builder**
    - **Assemble complete events from *n* time slices**
  - **Monitoring framework**
    - **Monitoring plots for detector electronics health and welfare**
    - **Subsystem monitoring**

Full detector commissioning

- Full detector commissioning (essentially the final stage of DAQ commissioning)
- Once a full detector “works” (which may come in stages, for example, 8 sectors of HCAL may be the complete detector at some point), it must be operated in concert with other detectors (the PHENIX equivalent of building up the “Big Partition”)
- Problems may require detector systems to return to previous stage for debugging and repair
- Pedestal measurement and testing with zero suppression
- Testing must demonstrate full speed operation with random trigger
- Many safety implications possibly requiring watch shifts to allow power to remain on
- Projected to begin about April 2022
- If we do the slice tests right, we’ll be able to switch the fibers and take data from the detector
- This would be the first full scale test, so there will be some bumps in the road

Beam operation

- Plan to start with a few 6 bunch stores, then transition to low intensity 110 bunch stores
- Possible startup plan:
  - **6 bunch, zero crossing angle, 5 stores**
  - **110 bunch, zero crossing angle, 5 stores**
  - **6 bunch, 2 mr crossing angle, 5 stores**
  - **110 bunch, 2 mr crossing angle 1 kHz/5 kHz/10 kHz/15 kHz 20 stores**
- Timing of MBD
  - **MBD-only data-taking**
- Trigger development with beam
  - **If we start with A+A, calorimeter trigger development could be parasitic**
- It may be possible to have detectors timed together so that detectors are all “close” in time at turn-on

sPHENIX Issues

- **Need continued effort from BNL PPM to complete upcoming sPHENIX procurements and contracts**. We still have $6M in procurements to place in the next 12 months including the MIE, 1008 I&F upgrade, MVTX.
- **Need to maintain this level of personnel support from BNL from now until the start of sPHENIX operations**. We have ~ 8 FTEs (technicians and engineers) from BNL Instrumentation working on sPHENIX or external dependencies (INTT). We also have 8-10 CAD FTEs (technicians and engineers) from CAD working on sPHENIX. Addition personnel from the Magnet Division also support sPHENIX.
- **Need to increase employees and visitors on site while working under COVID protocols.** Plan to increase number of sPHENIX persons on site from 35 FTEs now to 40 FTEs by mid-July and 45 FTEs by the Sept approved by BNL assuming continued progress on COVID.
  - **BNL Management has indicated this increase is likely even if BNL stays in Limited Operation mode.**

Summary

- **sPHENIX Assembly has started in 1008**
- Construction is proceeding on sPHENIX final detector components at a wide variety of sites.
- Continued great progress in sPHENIX factories: **OHCal sectors complete**, **65% of EMCal Blocks** and **42% EMCal sectors complete**. **All TPC chips tested**. **All MVTX staves complete**. Electronic, DAQ/Trigger, MBD, INTT, IHCal all making good progress.
- Majority of Major 1008 I&F parts are complete or on order.
  - **This includes the barrel and end cap flux return steel, LHe and LN2 components, cryo controls and power, carriage/cradle, the beam pipe modification, XY carriage tables, carriage hydraulics, carriage platform, Large Support Rings, various installation fixtures.**
- We have a large team of engineers and designers working remotely, and effectively on the design of the sPHENIX MIE.
- We have **35 FTEs** approved to work on BNL including visiting scientists and students.
  - **We typically have 25-30 people working on BNL site for sPHENIX in an average working day.**
  - **Expect the BNL authorized number to increase to 40 FTEs mid-July and 45 FTEs by September.**
- Early completion dates of MIE and 1008 I&F are holding constant despite COVID impact.

Back Up

Note on magnet operation

- sPHENIX taps into RHIC cryogenics system both for LHe and controls.
- Roberto Than (RHIC cryo) notes that “there is no starting ahead for sPHENIX”
  - **The magnet does not get to 4K until RHIC is started its cooldown of 4K.**
  - **Pre-run Cryo: Scrub Dec 2022**
  - **Pre-run Cryo: 45K Wave Jan 2023**
  - **Run starts & Cryo-weeks count starts: Feb 2023 and 4.5K wave starts in RHIC**
  - **Week 1: RHIC 4.5K Fill and sPHENIX cooldown**
  - **There is no "starting ahead for sPHENIX”**
  - **If everything goes according to plan, the LN2 system is supposed to keep the magnet at 90K if it stays inside the Detector Hall.**
  - **During the 4 weeks of 45K wave for RHIC we have the option to switch to 45K supply and get it colder than 90K.**
  - **When we start the RHIC 4.5K fill wave for the BLUE ring, we will have 4.5K helium and can start the solenoid cooldown.**

Cosmic ray running

- Magnet off
- “All” detector components energized
- Development/configuration/timing/testing of a CR trigger is possibly time-consuming
  - **Ideas to use variant of jet/Upsilon trigger**
- It is hard to see how a trigger of this complexity could be implemented before the presently scheduled beam operation

High Priority Issues

- Keep 1008 installation activities progressing forward.
- We need to keep the EMCal and IHCal assembly on schedule.
- Complete TPC Fee slice test, receive and test first article TPC Fee boards
  - The TPC Fee production assembly house has been awarded.
  - All SAMPA v5's have been tested by Lund and shipped to BNL.
  - Production Fee PCB ordered
- Keep all electronics on schedule (TPC, Calorimeter, MBD DAQ/Trigger)
- Complete remaining engineering design tasks and order components
  - We must finish the designs and move our attention to assembly, installation and testing.
- Schedule and hold remaining reviews
- Place Remaining procurements

OuterHCal and EMCal Installation

	Fabrication Complete	Installation Date	Delta (wk)
OHCal Sector 1 & Splice Plates	Week 8, 2021	Week 25, 2021	17
OHCal Sector 13	Week 5, 2021	Week 36, 2021	31
SC Magnet Coil	2018 (testing at BNL)	Week 39, 2021	>100
OHCal Sector 14	Week 5, 2021	Week 43, 2021	38
OHCal Sector 32	Week 17, 2021	Week 48, 2021	31
EMCal Sector 1	Week 14, 2020	Week 1, 2022	91
EMCal Sector 32	Week 26, 2021	Week 5, 2022	31
EMCal Sector 59	Week 52, 2021	Week 10, 2022	10
EMCal Sector 64	Week 5, 2022	Week 11, 2022	6

TPC and Electronics Installation

	Fabrication Complete	Installation Date	Delta (wk)
TPC	Week 4, 2022	Week 28, 2022	24
OHCal Cabling	Week 3, 2022	Week 5, 2022	2
EMCal Cabling	Week 3, 2022	Week 5, 2022	2
Digitizers	Week 44, 2021	Week 17, 2022	25
Trigger & Timing Systems	Week 4, 2022	Week 17, 2022	13
Beampipe	Week 8, 2022	Week 32, 2022	24

TPC, EMCal and OHCal on-detector electronics are installed as part of detector fabrication
Digitizer, Trigger and Timing installed after roll-in during April 2022
EMCal & HCal cabling starts only after Upper Platform in placed and essential cryogenics work is underway

Preparing for Cradle Installation 6/2/21

Carriage & Installation