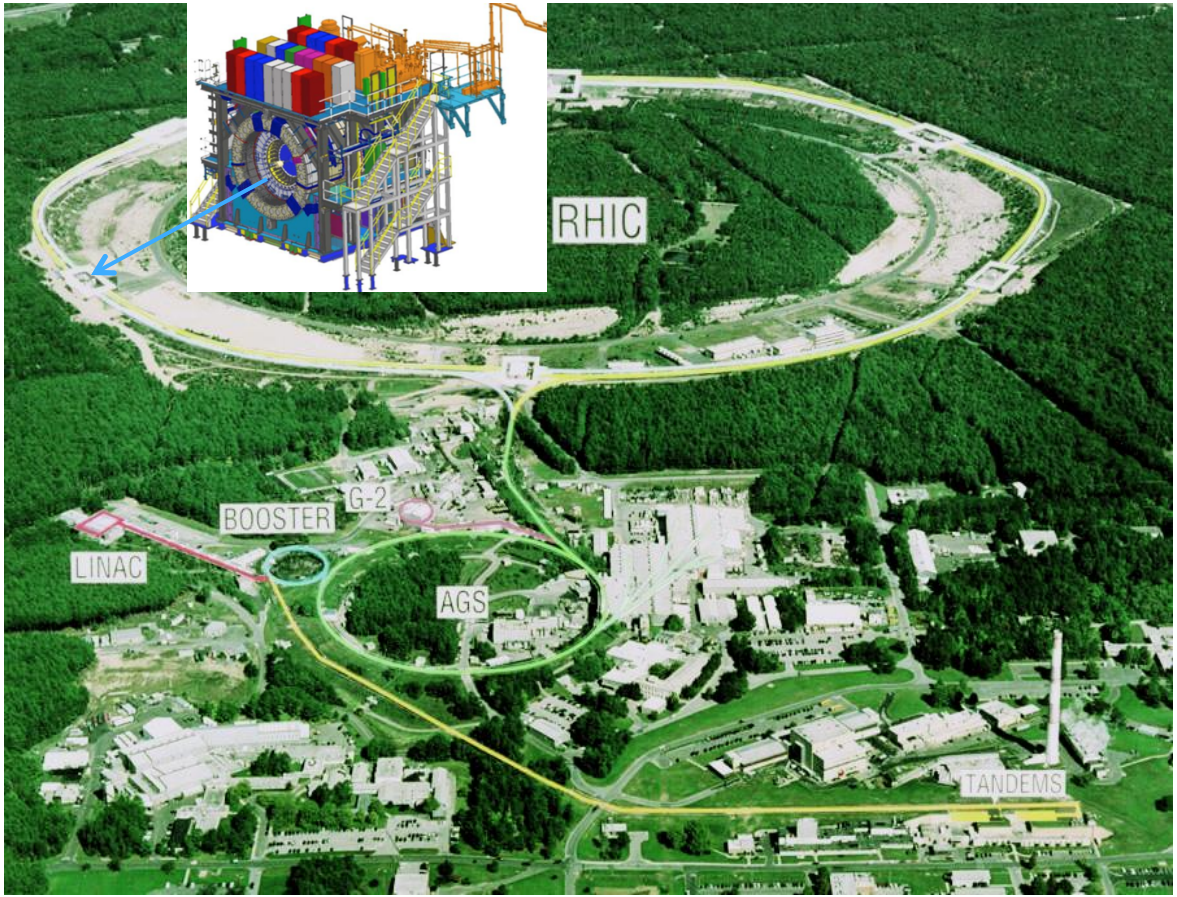

Brookhaven
National Laboratory
U.S. DEPARTMENT OF
ENERGY
The sPHENIX Project
Edward O'Brien
PAC
June 2, 2022
@BrookhavenLab

The sPHENIX Project



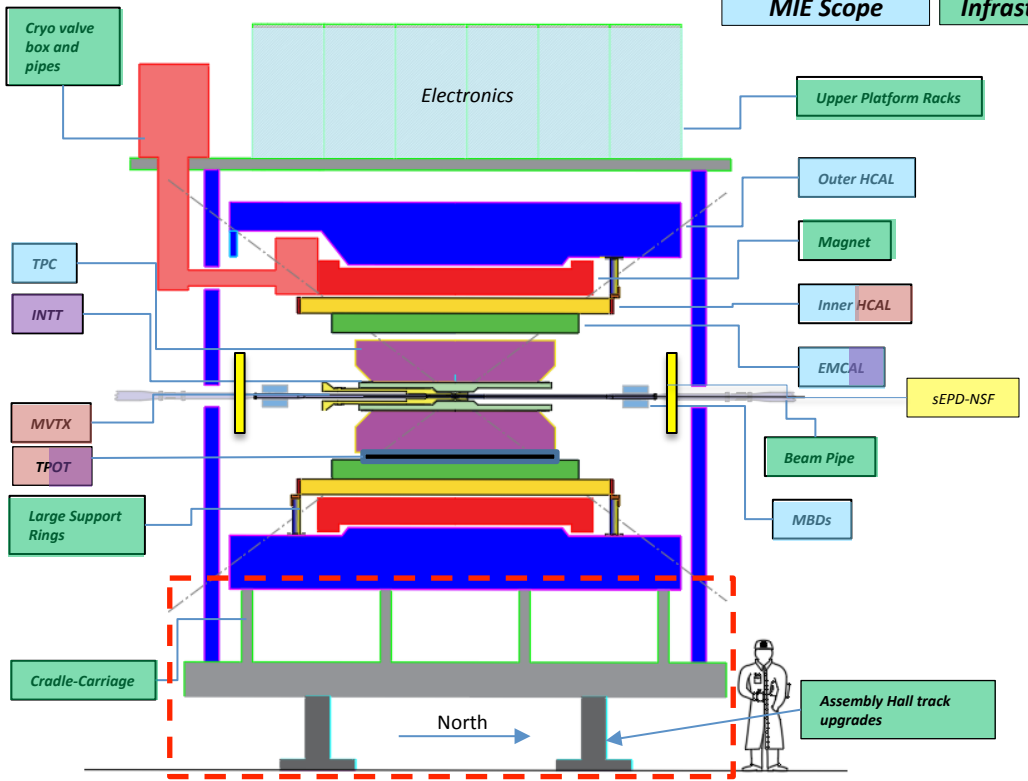
sPHENIX is a major upgrade to the PHENIX detector. It is a large-acceptance, high-rate detector for Heavy Ion physics that repurposes **>$20M** in existing PHENIX equipment, infrastructure and support facilities.

The detector is optimized to measure jet and heavy quark physics by incorporating a Time Projection Chamber, Electromagnetic and Hadronic Calorimeter with a high rate DAQ/Trigger and a 1.4 T solenoidal magnetic field.

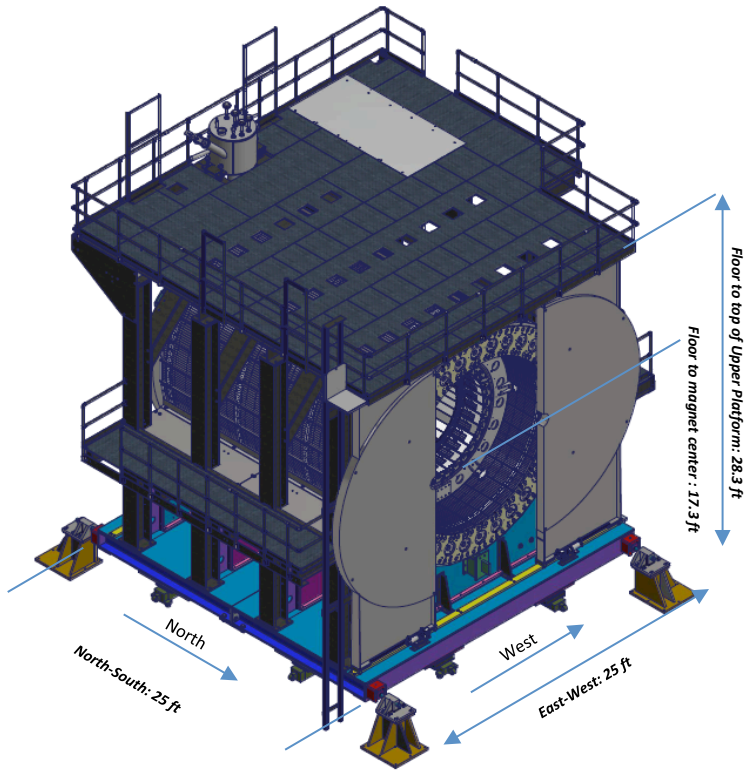
sPHENIX Elevation View and 3-D Model

MIE Scope | Infrastructure Upgrade Scope | International Contribution | BNL Capital Project

NSF funded



Elevation-view cross section of sPHENIX highlighting the nested detector structures and magnet return steel construction.



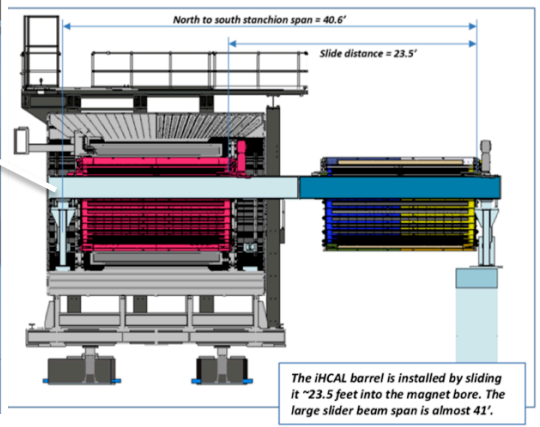
3D-model of sPHENIX looking at the north side with pole tip doors open and EMCAL installed.

sPHENIX Progress

We are making good progress, but there are many challenges ahead

Preparation for IHCal installation in 1008

- Preparations are underway for the installation of the IHCal in early June.
- Once the IHCal is installed we will begin to install the magnet pole tips. Installation of magnet brackets are done after having been surveyed and shimmed into position.
- Pole tip installation is followed by the magnet valve box and EMCal installation while work on the top platform continues.



sPHENIX Progress - continued

Begun practicing the EMCal sector installation into the IHCal barrel. Method looks good.

EMCal lifting fixture passed the BNL load test last week.

sPHENIX MIE Status

- **All OHCal sectors complete**, installed, tested.
- **All IHCal sectors complete**, assembled into barrel, tested. Installation prep has begun.
- **All EMCal sectors complete**. Electronics burn-in complete.
- **All Calorimeter on-detector electronics complete**, tested.
- **Calorimeter digitizers being assembled at vendor.** Assembly 95% complete at vendor. Will be done by mid-June.
- **All TPC det components at SBU w/ exception of laser system.** All 72 quad-GEM modules assembled and tested. Gain and IBF calibration underway. Prep for central membrane assembly
- **TPC FELIX boards complete.** TPC Fee boards need 1 chip added, minor FEE assembly mod and testing. JACK board waiting for 1st article before production order.
- **DAQ/Trigger: Large switch, DAQ computers, Buffer boxes, GTM/ GL1 complete**. Waiting on LL1 and DCMIIs
- **MBD detector complete.** Waiting for ICs to complete Discriminator/Shaper board.

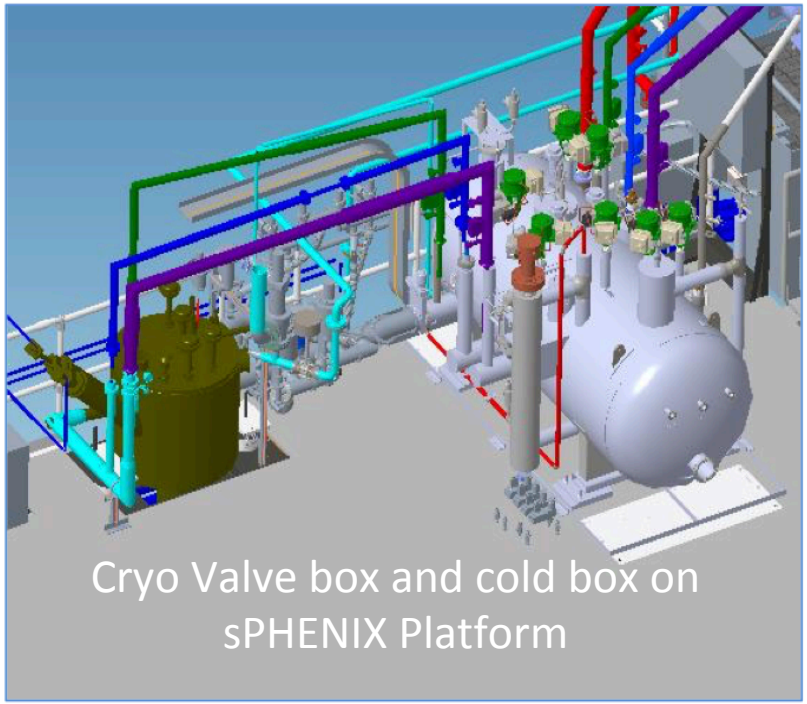
1008 Infrastructure & Facility Upgrade Status

- **Carriage/Cradle assembled in 1008**
- **XY Carriage tables, Carriage Hydraulics installed**
- **SC- Magnet installed in 1008**
- **EMCal Installation fixture completed at SBU**
- **IR track reinforcement complete.**
- **Large Support Rings installed**
- **Most LHe cryo components delivered.** Large cold box shipped this week
- **LN2 & warm piping part delivered, installation begun**
- **IHCal assembly/installation fixture complete and installation begun**
- **Magnet pole tips at BNL installation begins early June**
- **Rack Platform parts at BNL**
- **Chiller platform, TPC/MVTX/INTT installation fixtures and brackets in fab**
- Initiating Magnet Mapping contract w/ CERN
- Still to order: brackets and supports for Beam pipe, MBD, sEPD.

High Priority Issues

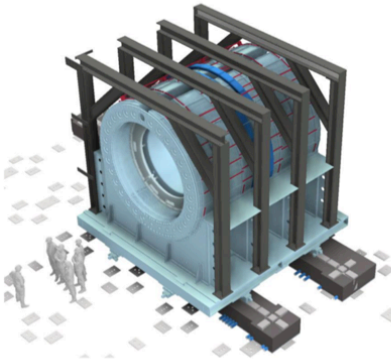
- Keep on schedule. No schedule float. We are looking for opportunities to regain schedule.
- Installation in 1008.
  - **Platform construction continues.**
  - **IHCal installation begun followed by Pole Tip Installation.**
  - **Install all cryo + cryo controls and protection + magnet power in prep for magnet mapping**
  - **Carriage roll-in to the IR in the period mid-July to early August.**
  - **Power carriage racks in IR.**
  - **EMCal installation schedule for July-August.**
  - **Magnet mapping schedule for September-October.**
- Complete the assembly of the TPC, INTT, MVTX, TPOT, sEPD
- Complete the unfinished electronics: Cal Digitizer Assembly/Test, LL1, MBD D/S, TPC Fee mod and test, JACK Board fab/test
- Maintain the sPHENIX technical work force.
- **Pass Safety reviews IRR and ARR**
- **Begin Run-2023 in late February**

Platform, Pole Tips, Cryo Assembly

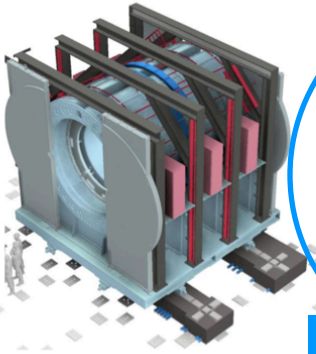


Cryo Valve box and cold box on sPHENIX Platform

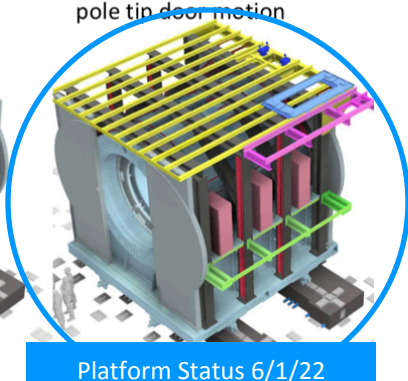
(1) Build superstructure



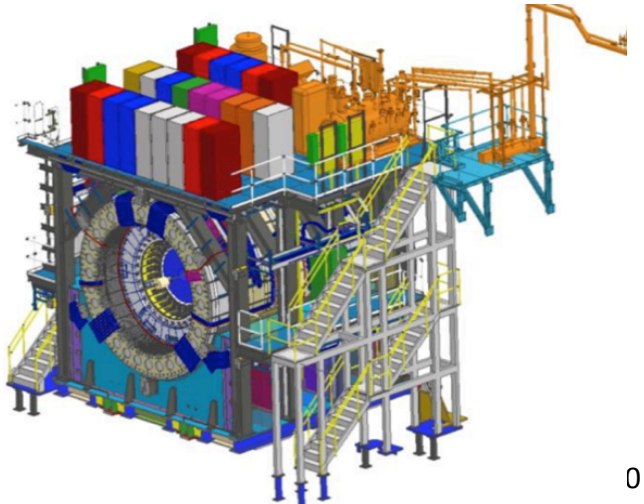
(2) Install trapped items



(3) Build Platform and test pole tip door motion

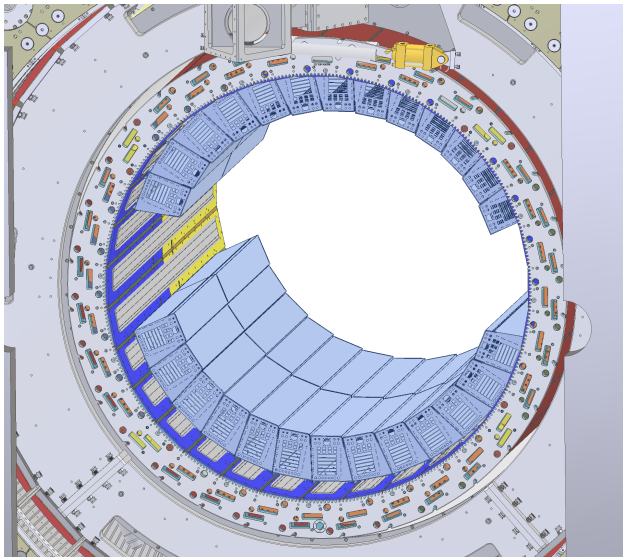


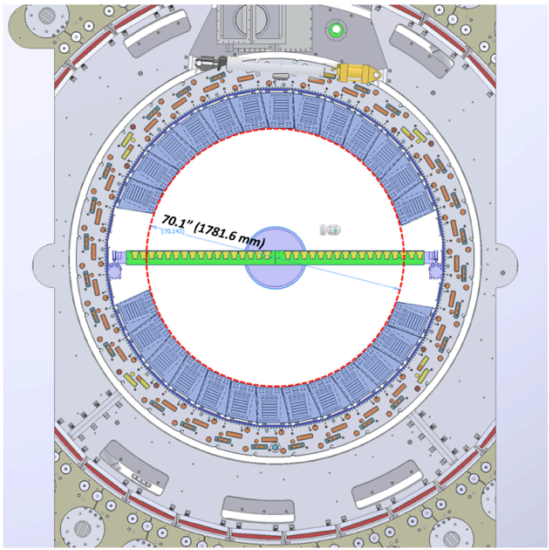
Platform Status 6/1/22

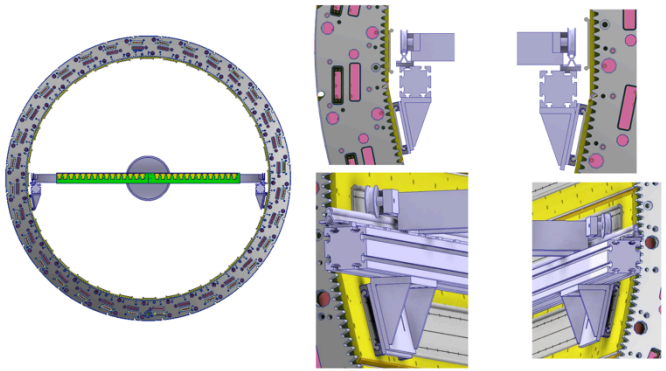


sPHENIX Configuration for Magnet Mapping

- **sPHENIX will contract with the CERN EP-DT group to map the B-field inside the magnet cryostat.**
- The CERN group will used a modified version of existing equipment used to map the ATLAS detector magnet at the LHC.
- Three sector slots (+/-Z) left open at 3:00 and 9:00 in ϕ to be used for mech support of magnet mapping apparatus
- The sPHENIX project team has started regular meetings with CERN Magnet mapping group in order to coordinate planned mapping activities scheduled for Sept-Oct 2022. A draft SOW exists that will form the basis of the contract between BNL and CERN.

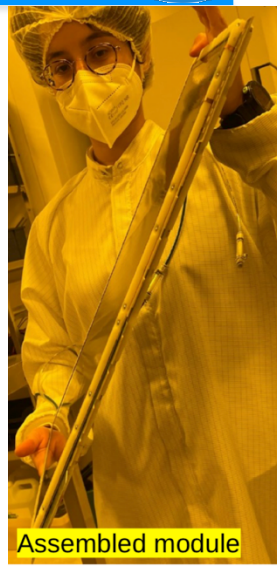


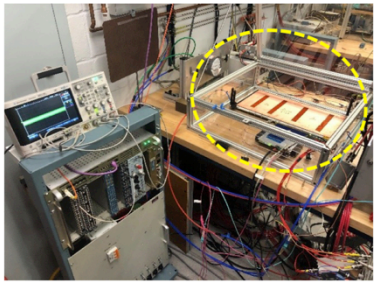




TPOT Status

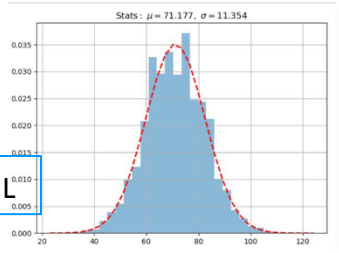
- Time Projection Outer Tracker (TPOT) will be composed of **eight, 2-layer micromega panels** mounted in the gap between the EMCal and TPC.
- Purpose is to provide a space point outside of the TPC to be used to correct for beam-induced space charge distortions in the TPC.
- The detectors are being made by Saclay,. The TPOT will use the readout electronics of the TPC.
- Ten TPOT panels will be built (8 production + 2 spares). To date Saclay has built four.
- One panels has arrived at BNL. The balance will be delivered between now the the first half of August.

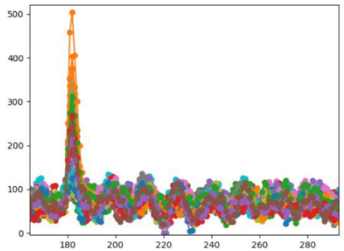

Assembled module


Testing of the TPOT prototype at BNL

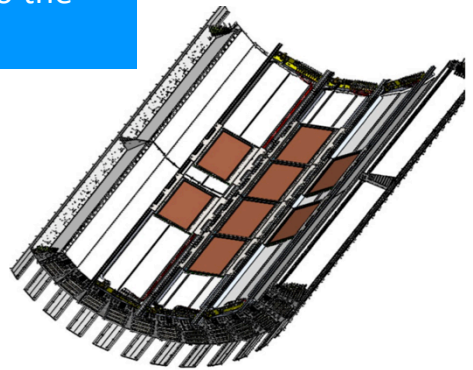
Initial tests (Jan 2022) with first prototype gave promising results:

- no oscillation of the FEE
- reasonable noise levels





8 TPOT panels mounted to the EMCal



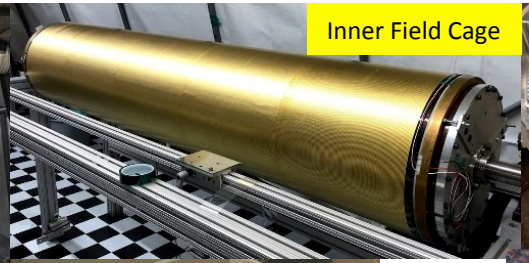
TPC Status

- Most mechanical components complete. Central membrane assembly in June
- Inner field cage complete
- Outer field cage complete in 4-6 weeks
- All 72 quad GEM modules complete. HV tests good
  - **50% quad-GEMs gain map and Ion Backflow characterization tests complete**
- All TPC Front End electronics cards exist. All at assembly house for addition of PLL and minor mod.
- All FELIX cards build and tested
- Laser calibration system components arriving from vendor.

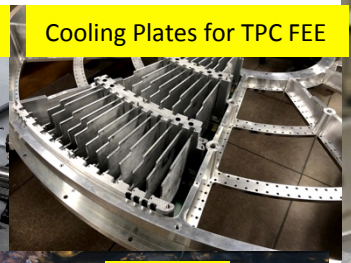
Quad GEM Test	Status
GEM HV Contacts (68/ mod)	Complete
GEM Over Voltage Stress	Complete
Gain Map	50% complete
IBF Map	50% complete
Radiation Load	50% complete

Outer Field Cage

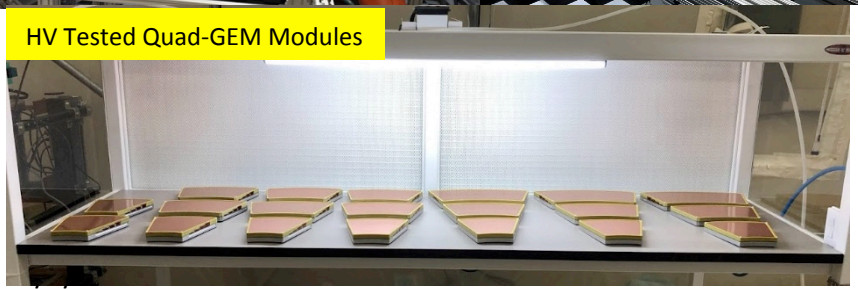
Inner Field Cage



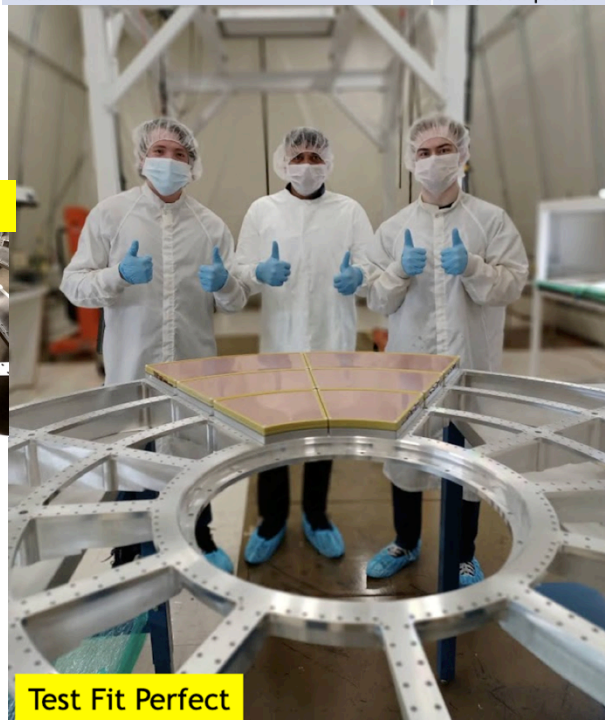
Cooling Plates for TPC FEE



HV Tested Quad-GEM Modules



TPC FEE



Test Fit Perfect

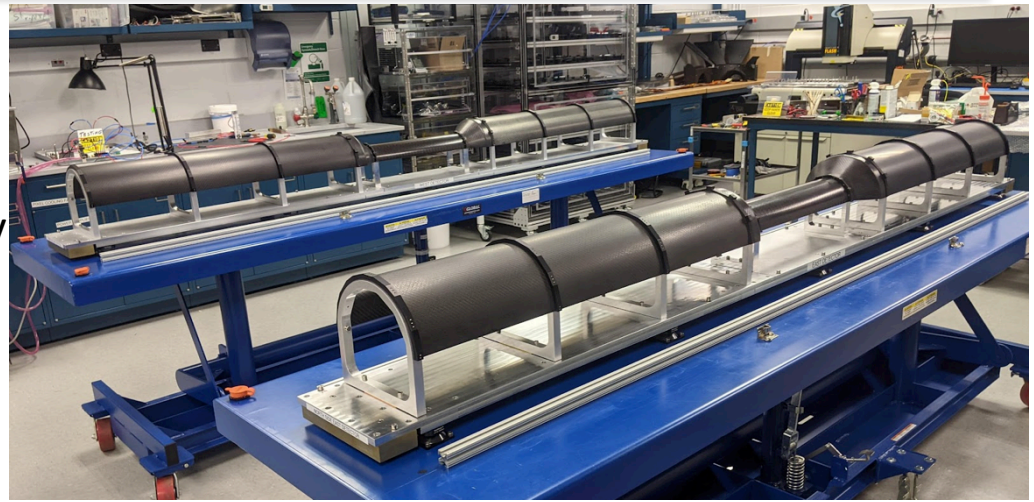
PAC

STAR Beam Pipe to sPHENIX

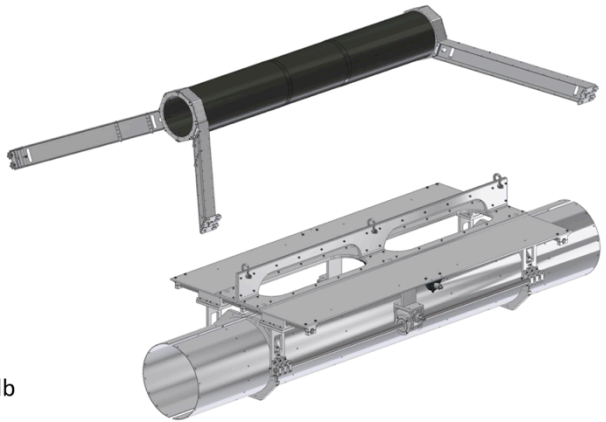
- STAR and CAD have successfully extracted the STAR HFT beam Pipe from storage and delivered it to the CAD Vacuum group
- The inside of the HFT Beam Pipe was scoped, and passed inspection

INTT Status

- All INTT **silicon strip staves** complete and tested.
  - **56 production staves + 66 spares**
- CF parts for ½ barrel fab manufactured by vendor and at BNL
- Aluminum support structure and installation fixture being made at vendors.
- INTT Half barrel assembly begins at BNL in June.
- **All electronics available.**
- On schedule for installation in January.

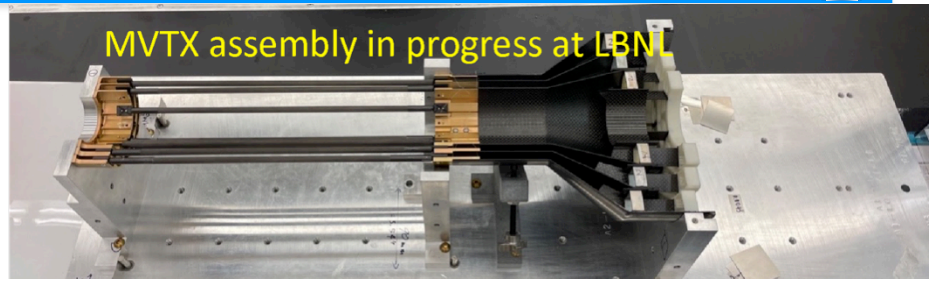


- INTT Support Structure
  - Facilitate INTT Installation
  - Install without crane
  - Support INTT Weight: ~125lb
  - Position INTT: +/- 0.125”
  - Support ROC Weight: ~100lb
  - Rout cables/fibers/cooling
  - Support Beam pipe
  - Withstand bake out
  - Integrate with MVTX and TPC
- INTT Install Fixture
  - Facilitate INTT Installation
  - Install without crane
  - Support INTT Weight: ~125lb



MVTX Status

- **All MVTX silicon pixel (MAPS) staves complete and tested**
  - **48 production + 36 spares @ LBNL**
  - **Half plane assembly underway at LBNL**



Complete:

- 60 SamTec cables
- CFC support
- SB power cables
- **60 Readout Unit**
- 30 Power Units
- **8 FELIX cards**
- CAEN power system
- Stave cooling system
- Insertion system

In progress:

Half-detector assembly

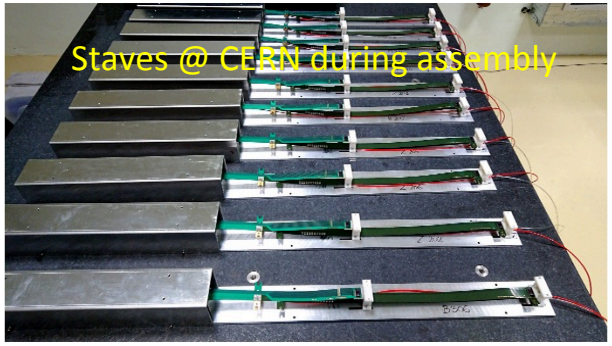
Rack cooling system

Long power cables

FELIX board testing

DCS PLC hardware

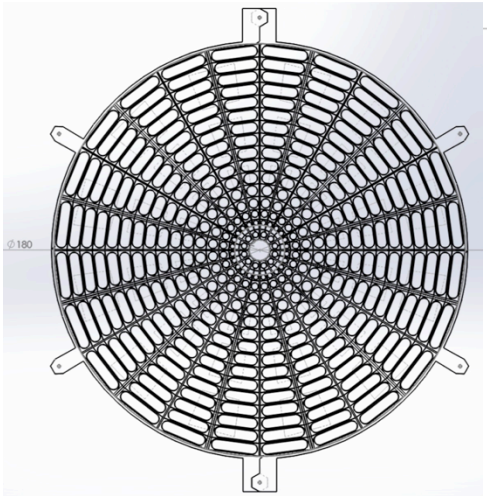
Lab + cleanroom being set-up at BNL for the arrival of the MVTX ½ barrels.

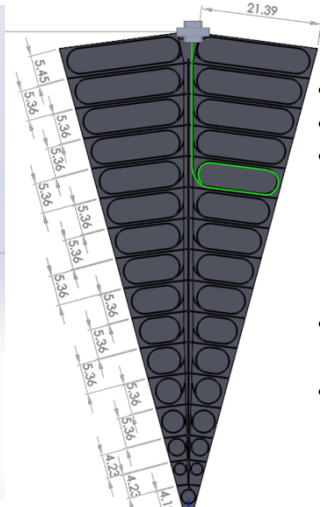


MVTX half −barrels to be delivered to BNL 2nd half of July

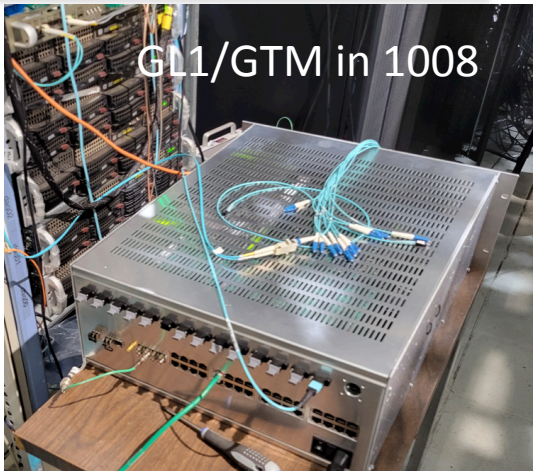
sEPD Status

- sPHENIX Event Plane Detector (sEPD) is two disks of scintillating tiles located at forward pseudorapidities in order to define the reaction-plane in collisions.
- NSF funded.
- The tile and disk arrangement is modeled after a very similar detector for STAR.
- Last subdetector to be installed in sPHENIX.
- Detector Construction due to be completed end of August.
- Installation schedule for January.





Overall sPHENIX Electronics Status



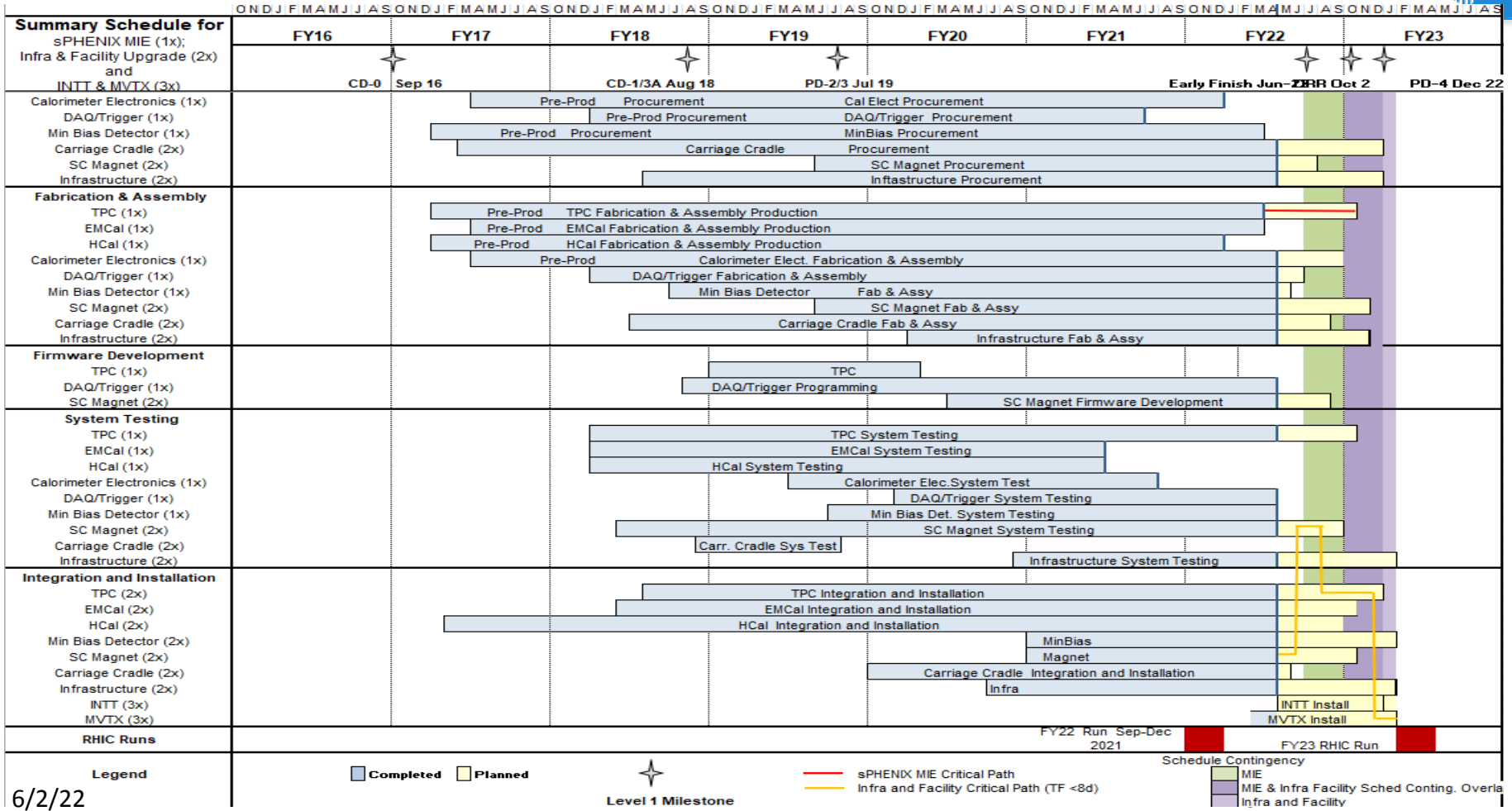
Completed or underway:

- All on-detector calorimeter electronics delivered and tested
- All LV and Bias supplies delivered.
- All signal, LV cables delivered or on order.
- All fibers and patch panels delivered or on order.
- GL1/GTM complete. Testing underway.
- All MVTX readout electronics delivered and tested.
- 95% of calorimeter digitizers assembled. Completed by mid-June. Testing underway
- All FELIX cards for TPC, MVTX, INTT delivered. Firmware development underway.
- All TPC Fee boards assembled, however need a PLL chip added and a couple small mods by vendor followed by testing.
- Parts for LL1 available. Need assembly and testing

Missing chips needed to complete electronics:

- Min Bias Det: Need 16 Discriminator/Shaper boards : LDO and line driver
- DAQ/Trigger: Need 6 DCMIIs - Stratix III FPGA

Summary Schedule – sPHENIX MIE and 1008 Infra and Facility Upgrade



Installation Schedule Highlights and Milestones

Remove the shield wall after RHIC Run-22	4/19 – 5/6
Install the magnet pole tips and cryo on the platform in the Assembly Hall	5/9 - 7/15
Install the IHCal	6/14 - 7/15
Roll carriage into the IR	7/18 - 7/22
Complete the magnet cryo/power/controls hook up in the IR	7/25 – 9/1
Install the EMCal in the IR	7/25 – 9/1
Magnet mapping	**9/9 – 10/10**
Install TPOT	10/10 - 10/24
Install the TPC	10/25-11/28
Beam pipe installation and bake out	12/6 - 12/27
IRR complete	**12/16**
ARR complete	**1/13/23**
Install silicon and trigger detectors	12/29/23 – 2/13/23
Begin RHIC Run-23	**2/22/23**

Depending on the task we are a little ahead, or a little behind schedule. We revise the schedule as needed

Risks and Challenges

- **Maintaining labor force for the next 10 months**. Especially important are:
  - Technicians for fab and assembly and installation
  - Visiting students, postdocs and scientists for QA, testing and commissioning.
  - We have been successful in borrowing techs from other parts of BNL.
- **Global issues may affect the cost and schedule of the project going forward**
  - Significant cost increases have been seen on certain raw material and machine shop work potentially impacting the 1008 I&F remaining costs.
  - Some items, like electronic chips, have very long lead times**.** Primarily an MIE issue.
- **Need BHSO USI approval for Magnet Mapping in Sept-Oct** (helium cool down begins in August)**. Need BHSO ASE/SAD approval for sPHENIX Operations in RHIC Run-23 beginning Feb 2023.**

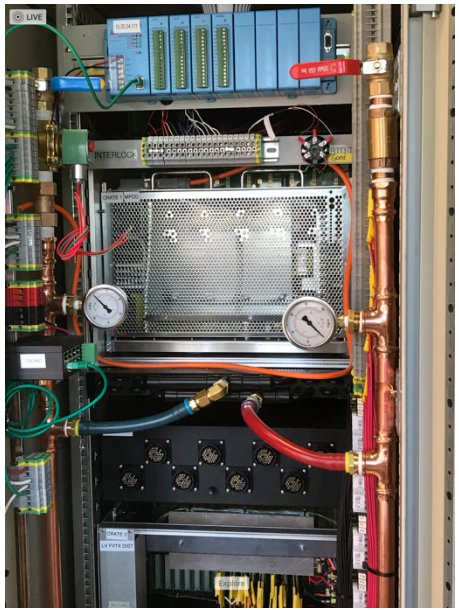
Summary

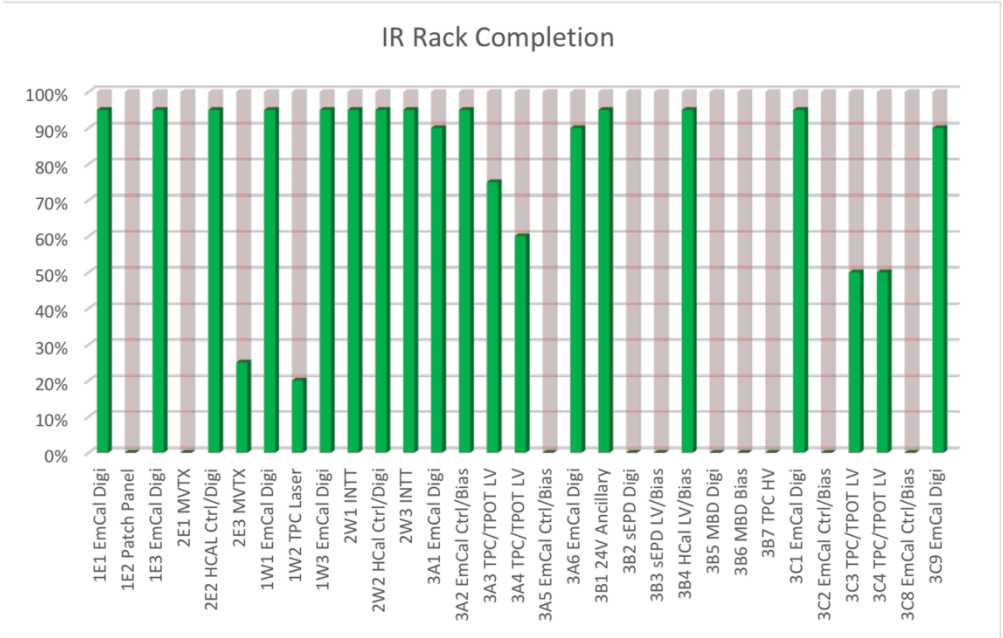
- **sPHENIX installation is proceeding well.**
  - **IHCal Barrel installation has begun. Magnet pole tips are next. Platform assembly is advanced.**
  - **EMCal sectors are complete and ready to install.**
- **The Cryo installation and magnet mapping is on the critical path, as is the TPC detector assembly.**
- Most major sPHENIX, 1008 I&F parts are complete or in fab
  - **We have a small but important subset of I&F orders to place including:** Magnet mapping contract w/CERN, MBD/sEPD/beampipe bracketry.
  - Need to order one more electronics board(controller) for TPC plus fibers for laser distribution.
- Engineering design is 99% done. Transitioning to fab/assembly oversight, installation and integration.
- **We have been successful in securing technicians and engineers from other parts of BNL: CAD, IO, SMD, NSLSII**
  - Need to maintain this level of technical support until the start of RHIC run 2023.
  - sPHENIX Collaborators continue to make critical contributions in the factories and home institutions.
  - sPHENIX has been fully funded by DOE and strongly supported by BNL Management including CAD, ATRO.
- The sPHENIX is supported by a large international collaboration of 80+ institutions, all awaiting the first run of sPHENIX in 2023.
- **Challenges remain:** We are missing a few Long-lead electronics chips, USI approval for magnet mapping followed by ASE/SAD, overall installation schedule has no float to start up date of RHIC Run-2023.

Back Up

Rack Production Update

Rack plumbing has begun





First 6 Racks installed on carriage.
Need 31 carriage racks total

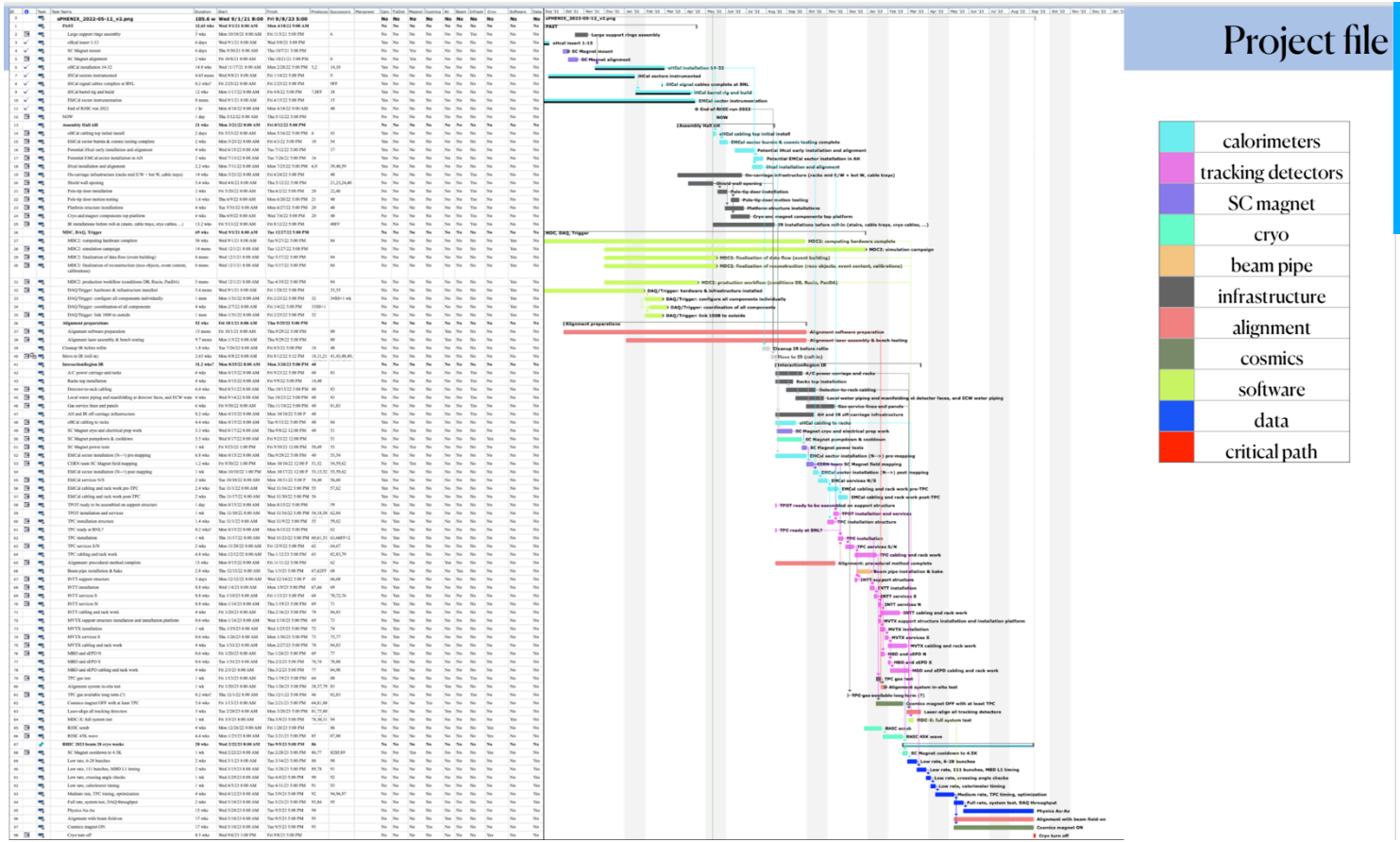
sPHENIX Commissioning Task Force

Name	Institution
John Haggerty	BNL
Caroline Riedl	UIUC
Walter Sondheim	Los Alamos
Ming Liu	Los Alamos
Klaus Dehmelt	Stony Brook
Jin Huang	BNL
Takao Sakaguchi	BNL
Rachid Nouicer	BNL
Stefan Bathe	CUNY
Tim Rinn	UIUC
Martin Purschke	BNL
Chris Pinkenburg	BNL
Russ Feder	BNL
Steve Boose	BNL
Joel Vasquez	BNL
Hugo Pereira	CEA Saclay / LANL
Rosi Reed	Lehigh University

sPHENIX Commissioning Task Force:
Co-Chaired by John Haggerty BNL & Caroline Riedl UIUC
Meet weekly since May 2021
Representatives from each detector subsystem plus
Lead engineers for Installation, Infrastructure, electronics

Are generating a detailed commissioning plan including a commissioning schedule and a Run-2023 start-up sequence.

Installation/Commissioning Schedule



sPHENIX Commissioning schedule is aligned with the sPHENIX installation schedule and our project P6 file

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)** main funding by RIKEN Lab –Japan with additional US and international funds.
- **Time Projection Outer Tracker (TPOT), BNL capital ($0.6M) +** additional US and international fund.
- 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)**

Critical Path (1x, 2x and 3x Combined)

POM02 sPHENIX WBS 1.x, 2.x April 2022 | PMG - Critical | 1 of 1

WBS Path	Activity ID	Activity Name	At Completion Duration	Start	Finish
01.02.01.02	S110400	Assemble TPC v2 Outer Field Cage	499	01-Jun-20 A	27-May-22
01.02.01.02	S111900	Assemble TPC v2 Central Membrane	499	01-Jun-20 A	27-May-22
01.02.01.02	S112000	Assemble TPC v2 Field Cage Prototype	266	11-May-21 A	02-Jun-22
01.02.05.04	S143300	Perform QA Testing on TPC FEE	215	18-Oct-21 A	25-Aug-22
02.05.09	EXT327600	[External Activity] INTT Assembly Complete and Ready for Installation	0		25-May-22*
01.02.01.08	S121800	Test TPC by sectors Prior to Installation	55	09-Jun-22	25-Aug-22
01.02.01.02	S112200	TPC Field Cage Safety Review	1	17-Jun-22	17-Jun-22
01.02.01.02	S112300	Final Design Review - TPC Field Cage	2	20-Jun-22	21-Jun-22
01.02.01.08	S121600	Production Readiness Review for TPC Final Assembly	1	22-Jun-22	22-Jun-22
01.02.01.08	S121610	Install TPC Modules into Field Cage	36	23-Jun-22*	12-Aug-22
01.02.01.08	S121700	Install TPC Electronics by sectors	10	29-Jul-22	11-Aug-22
01.02.01.08	S121900	TPC Ready to Install (Assembly Complete)	0		25-Aug-22
01.01.01	S101020	Internal Project Float	0	26-Aug-22	26-Aug-22
01.01.01	S101022	Early Project Completion	0		26-Aug-22
01.01.01	S101030	WBS 1X Schedule Contingency	84	26-Aug-22	29-Dec-22
02.05.12	S1008550	C-AD RSC Approval of sPHENIX SAD, ASE, and USI for start prior ARI	0		26-Sep-22*
02.05.12	S1008560	LESHC Approval of SPHENIX SAD, ASE, and USI	0		03-Oct-22*
02.05.12	S1008600	ESH ALD Provides Required Information and Requests Approval for sF	0		11-Oct-22*
02.05.12	S1008640	BHSO Approves sPHENIX ASE	0		12-Dec-22*
02.05.12	S1008680	Complete Internal Readiness Review	0		16-Dec-22*
01.01.01	S101040	Approve Project Closeout PD-4	0		29-Dec-22*
02.05.12	S1008720	Close IRR Pre-ARR Items	0		06-Jan-23*
02.05.12	S1008760	Complete Accelerator Readiness Review	0		13-Jan-23*
02.05.12	S1008800	Close ARR Pre-Operations Findings	0		23-Jan-23*
02.05.12	S1008840	Obtain ARR Team Recommendation for sPHENIX Commissioning	0		30-Jan-23*
02.05.12	S1008880	ESH ALD Provides Required Information and Request Approval for sPH	0		07-Feb-23*
02.05.12	S370800	sPHENIX Ready for Operations	0		14-Feb-23
02.05.12	S1008920	BHSO Approves sPHENIX Commissioning	0		14-Feb-23*
02.05.12	S370900	Start of RHIC Run 30-Jan-23	0	15-Feb-23	
02.05.12	S999999	Completed: sPHENIX MIE and Support Projects	0		15-Feb-23
02.05.12	S370850	WBS 2X Schedule Contingency	0	15-Feb-23	15-Feb-23