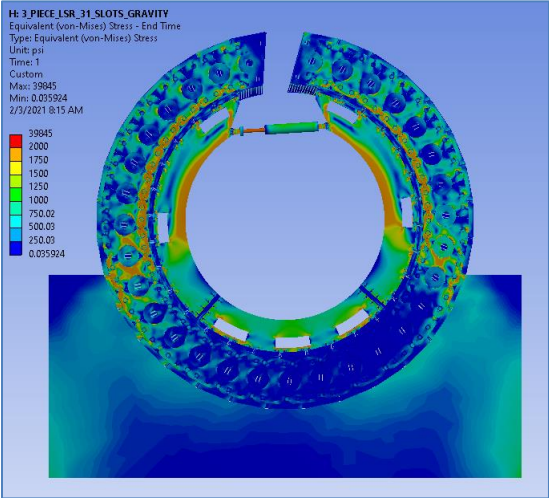


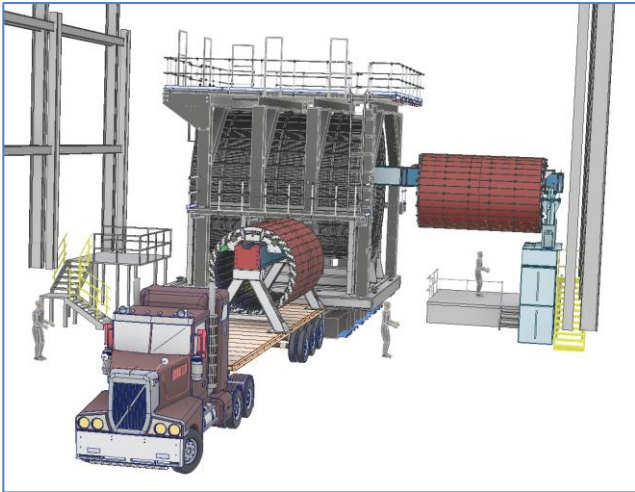
sPHENIX Annual MIE Review

Integration and Installation

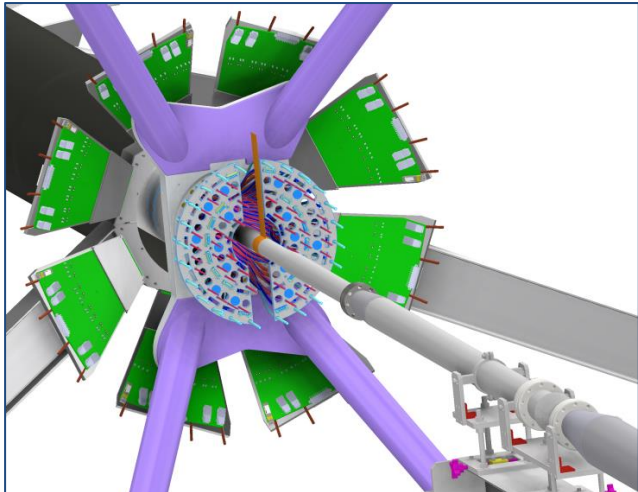
Russell Feder July 14-15, BNL



oHCAL construction engineering



iHCAL installation choreography



INTT-MVTX-Beam Pipe Integration

sPHENIX construction is underway (Status on 7/14/2021)

- The 1008 shield wall is being dismantled with the sPHENIX cradle-base pushed east towards the roll-up door
- oHCAL construction will resume the week of July 26th



The shield wall pushed open

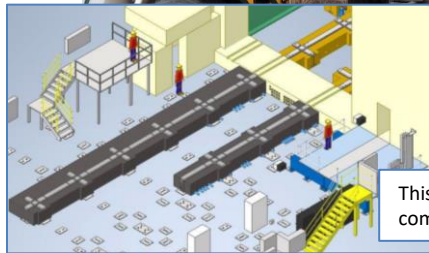
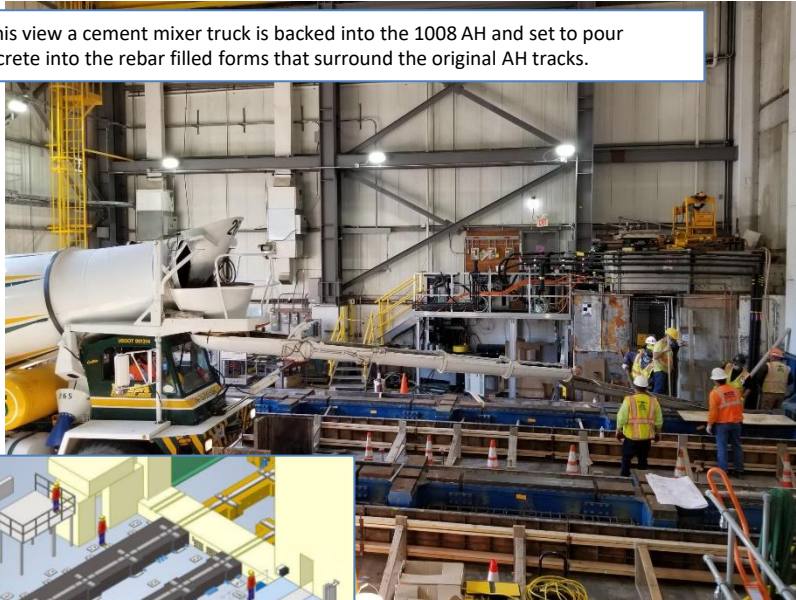


Looking at the sPHENIX cradle-base and dismantled shield wall blocks standing inside the IR

1008 floor and track upgrades

March to May, 2021

In this view a cement mixer truck is backed into the 1008 AH and set to pour concrete into the rebar filled forms that surround the original AH tracks.

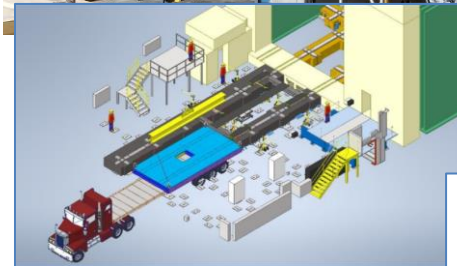


This CAD model view shows what the completed AH tracks look like (dark gray)

Cradle-base installation

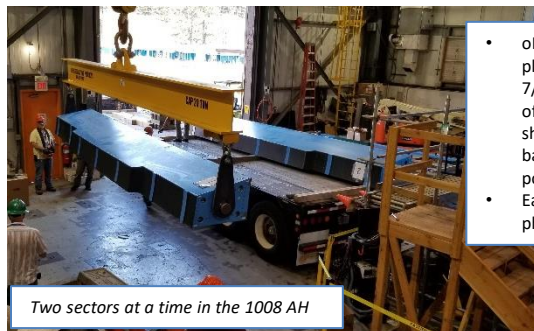
May and June, 2021

sPHENIX construction safety: notice scaffolding and access stairs. Elevated work precautions.



This CAD model view shows a flatbed delivering one of the 36-ton cradle-base halves to the 1008 AH.

oHCAL installation has started



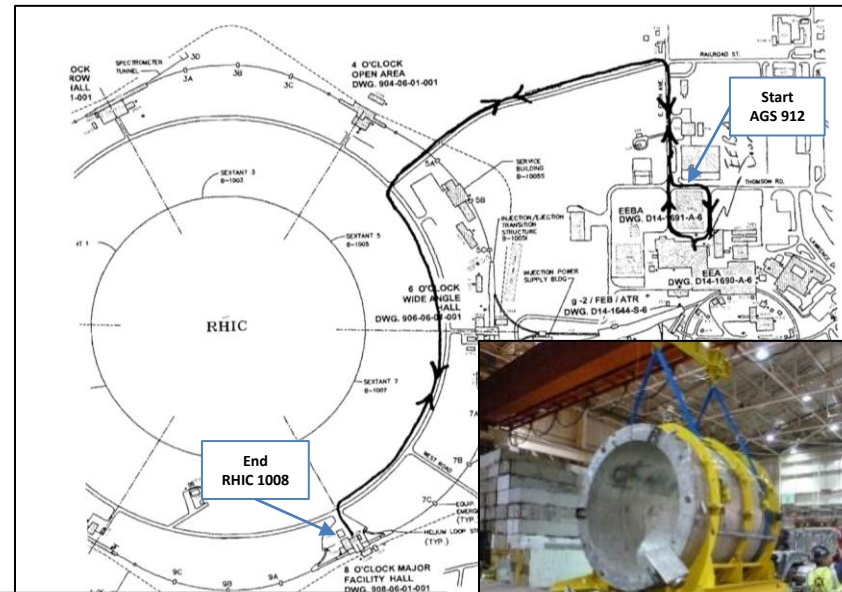
Two sectors at a time in the 1008 AH

- oHCAL “keystone” sector #1 was precisely placed and secured to the cradle-base on 7/1/21. Assembly work will re-start week of July 26th (or sooner) after the 1008 shield wall is removed and the sPHENIX base is placed back in construction position.
- Each oHCAL sector is tested by the oHCAL physics team after transport to 1008.



Each sector requires a team of 4-5 sPHENIX techs and CA-D riggers to install

Babar magnet ready for installation

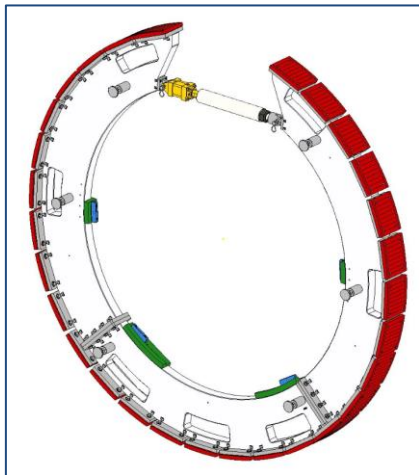


- The Babar magnet is driven on an air-ride flatbed truck from AGS building 912 to RHIC building 1008 in a special carrying cage. This is a photo from when the magnet was delivered to BNL from SLAC.

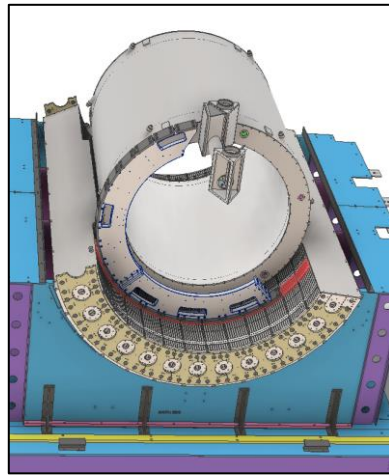


Build the large support rings

- After the magnet is landed the north and south Large Support Rings (LSRs) are installed.
- The LSRs, fabricated from high strength aluminum alloy, help to support the remaining oHCAL sectors and support all the other SPHENIX detectors through the iHCAL barrel.



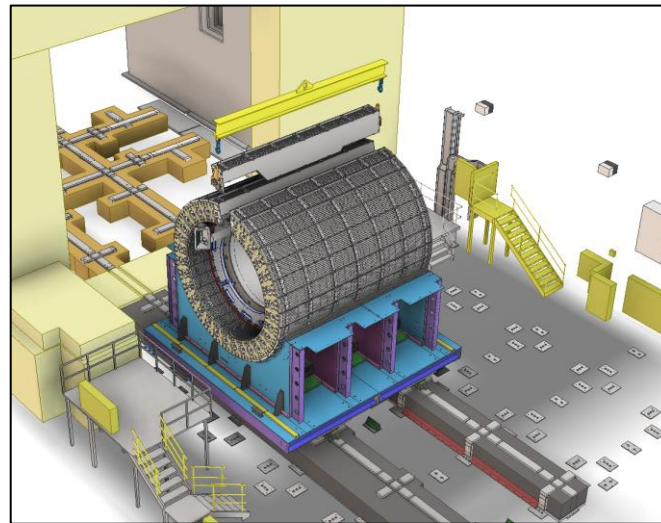
One of the Large Support Rings. The green tabs are the iHCAL supports.



The LSRs are built in place out of three sectors lowered down by the overhead crane.

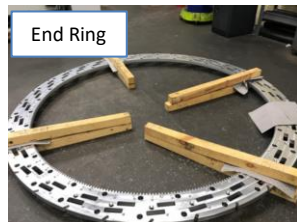
Complete the oHCAL barrel around the magnet

- oHCAL sector 32 is the final oHCAL sector to be lowered into place. The installation of oHCAL sectors 14-32 are each “critical lifts” because the lift is over the irreplicable Babar magnet.
- The LSRs have powerful hydraulic pistons at the top that can be used to pry open the oHCAL barrel to ensure sector 32 can be fit in. The pistons are removed before the iHCAL is inserted.

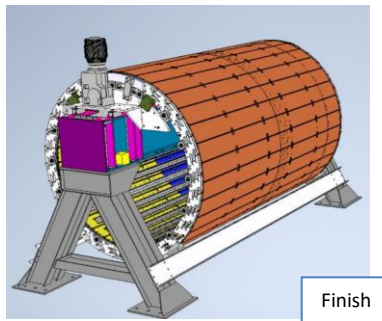
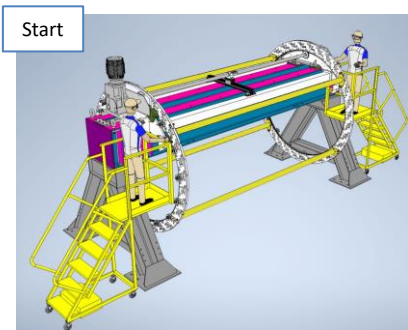


iHCAL factory and barrel fabrication

- The iHCAL barrel is the primary support structure for all of sPHENIX detectors inside the magnet bore (EMCAL, TPC, INTT, and MVTX)
- The first eight iHCAL sectors are in building 912 ready to be filled with tiles and electronics
- We have also received the iHCAL barrel end rings

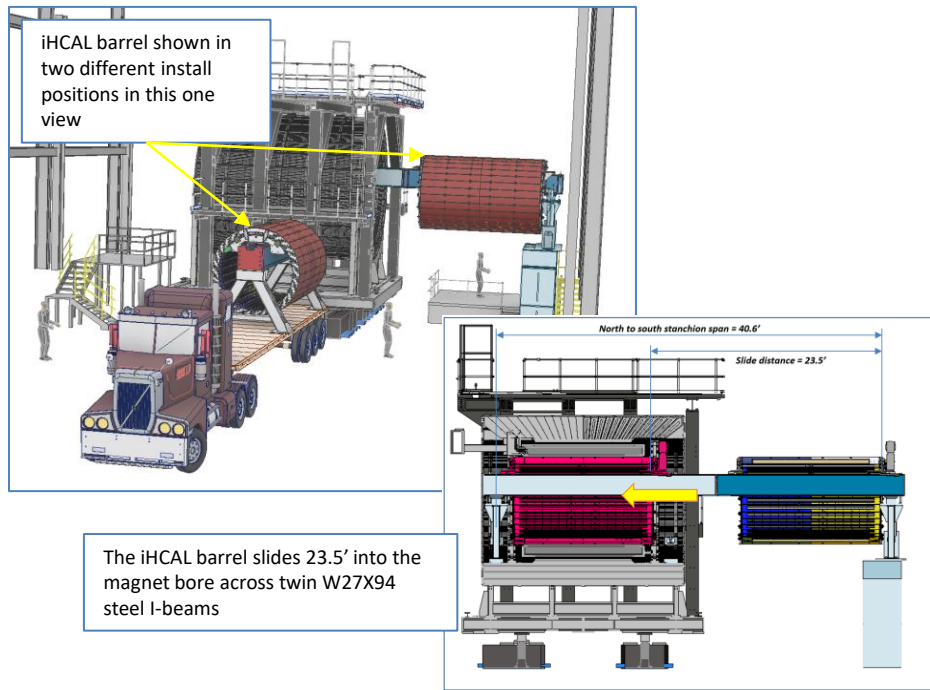


- Procurement of the iHCAL barrel fabrication rig has started



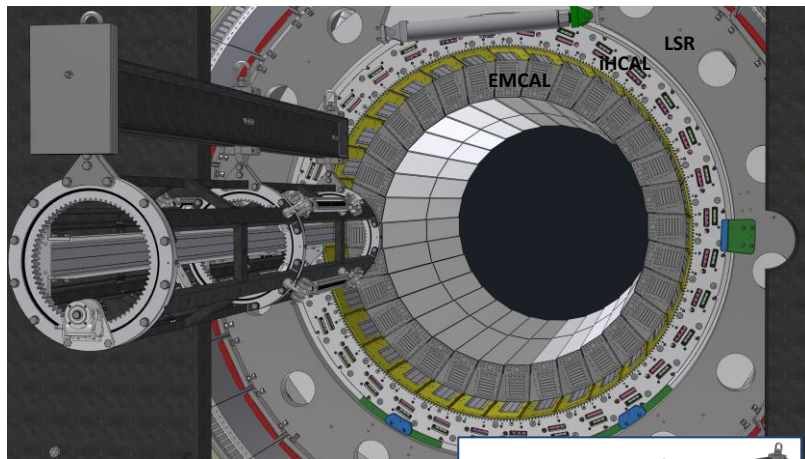
iHCAL installation structures design

- The iHCAL barrel is fabricated on the north installation slider beam. The whole rig is lifted off a flatbed truck and placed on the installation stanchions. The barrel slides 23.5' into the magnet bore and rests on the large support rings.



EMCAL installation

- Two EMCAL sectors at a time are positioned and pulled onto guide rails. The guide rails are pre-installed inside the iHCAL bore. In this view the EMCAL install fixture is shown near one of the opened pole tip doors.

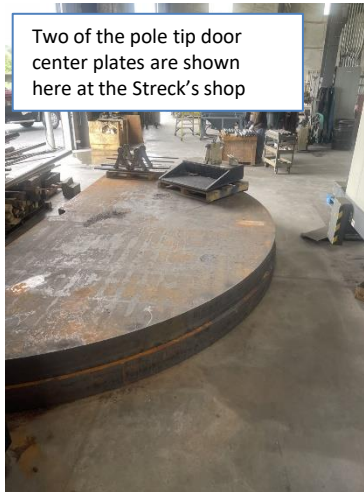


The EMCAL install tool is a below-the-hook lifting and rotating device. It is currently being fabricated at SBU.



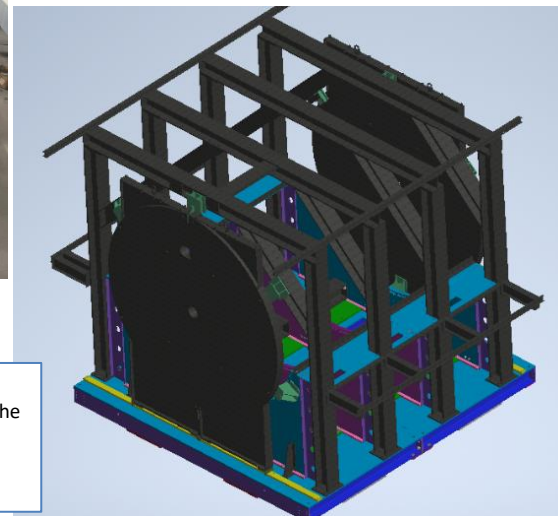
Carriage, Platforms and Pole Tip Doors

Two of the pole tip door center plates are shown here at the Streck's shop

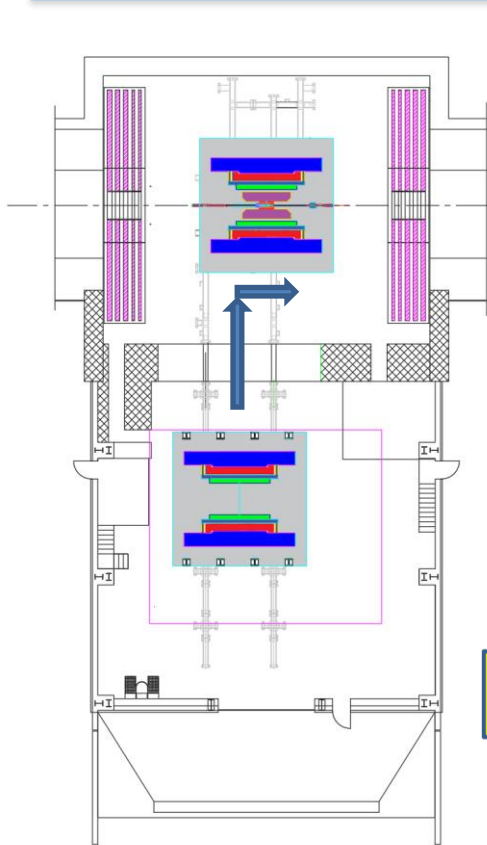


- The carriage superstructure and the pole tip doors are being fabricated at Streck's in upstate NY. The vertical east and west carriage columns can be installed once the oHCAL barrel is complete.
- Each pole tip door half weighs 23 tons and will be installed before the upper platform once the superstructure is in place.

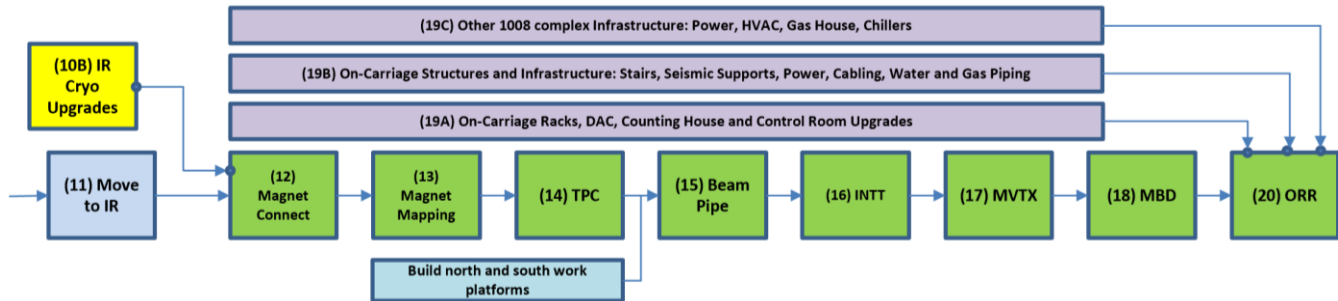
There are many large structural components bolted together to form the carriage superstructure. The structure wraps around the completed oHCAL barrel (not shown in this view).



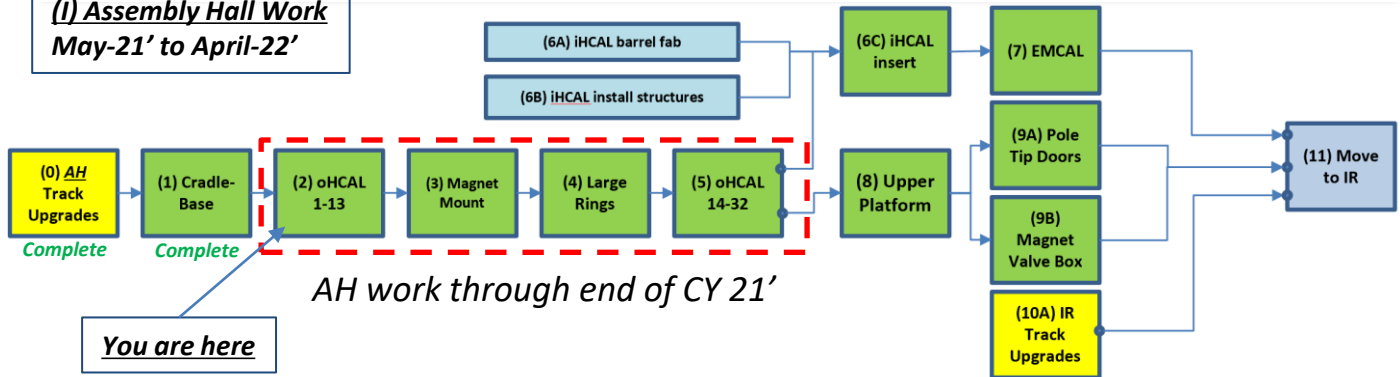
sPHENIX Assembly Sequence



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



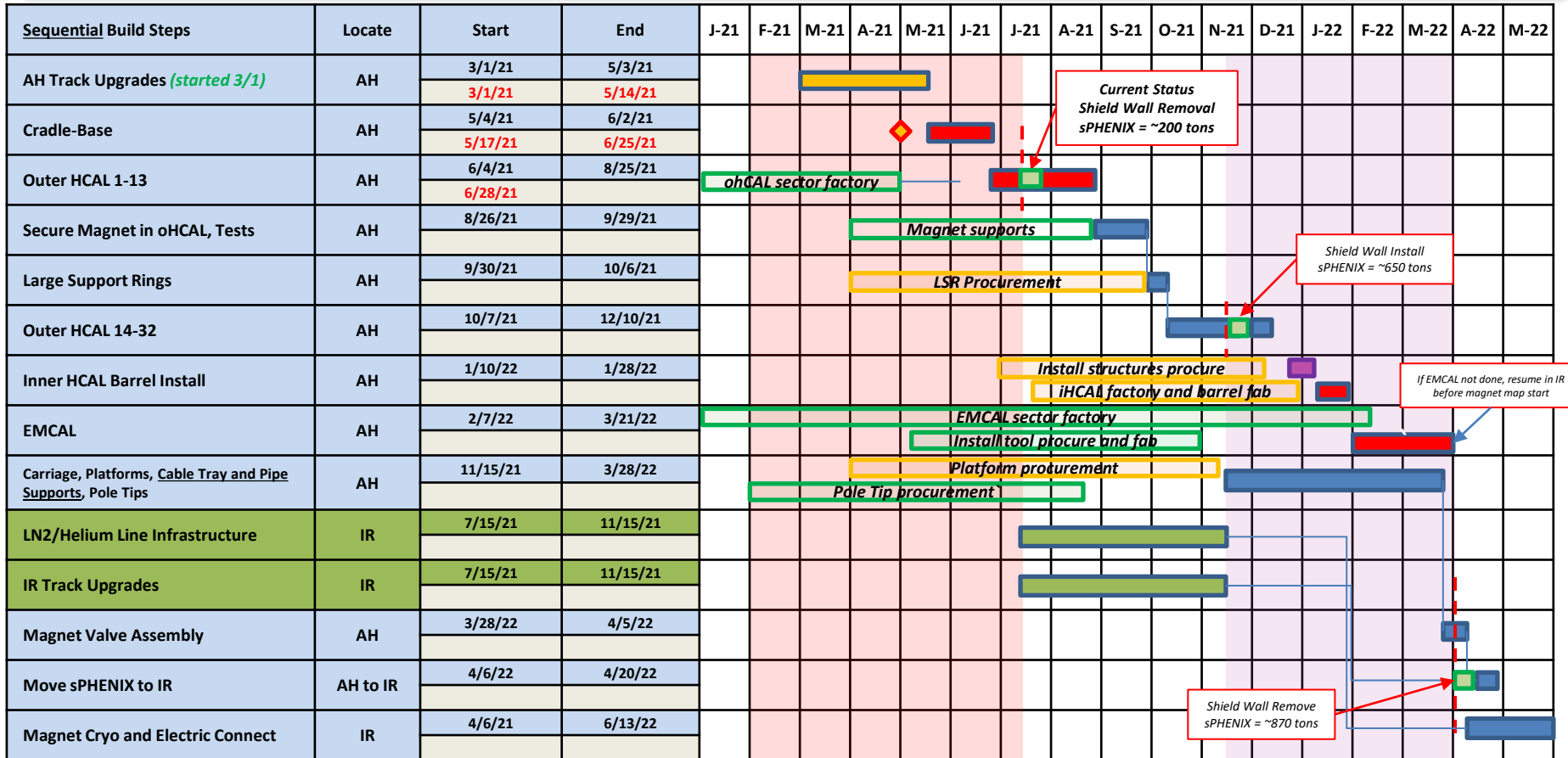
(I) Assembly Hall Work
May-21' to April-22'



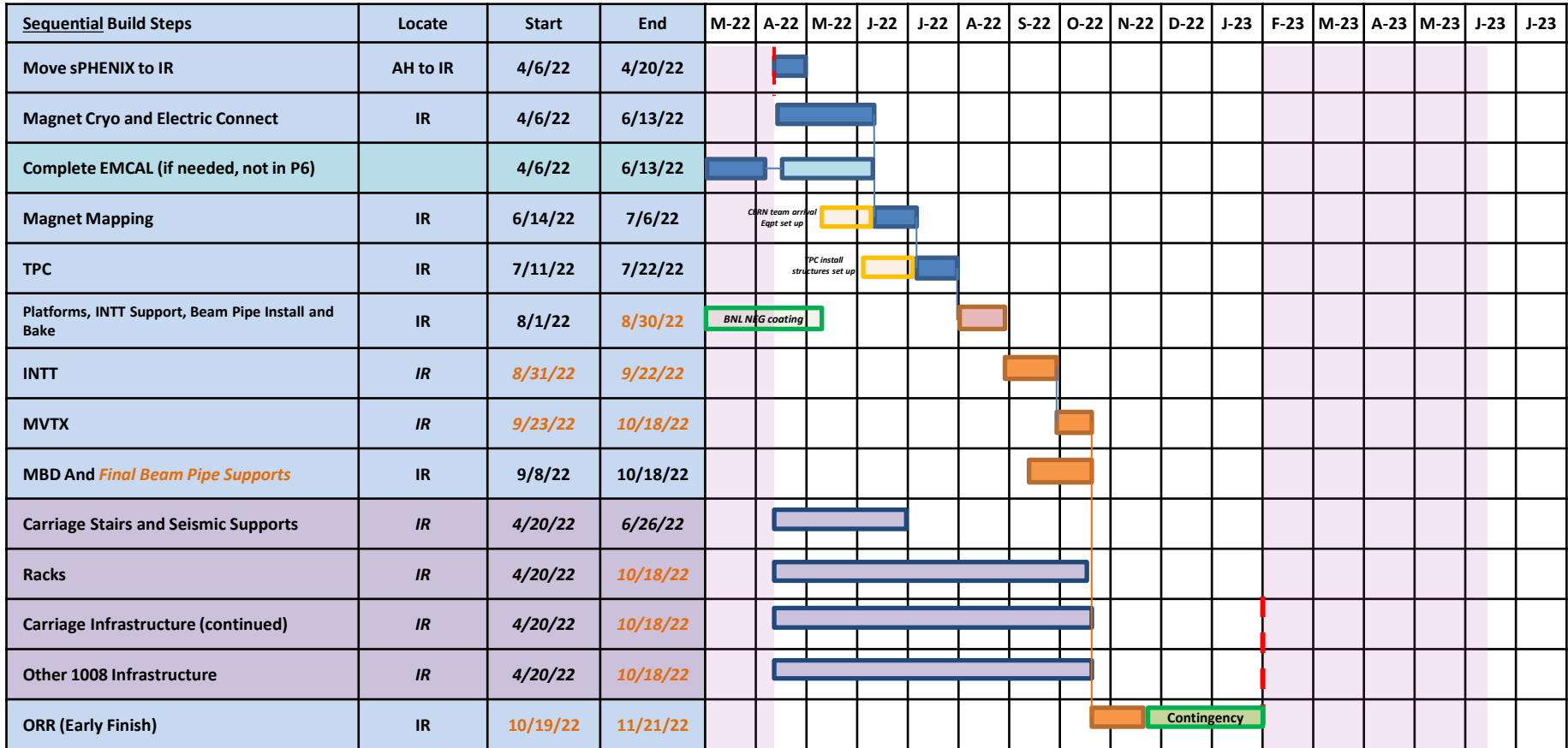
sPHENIX AH Installation Schedule

Dates from April 21' I&F review
Actual AH starts

| | |
|--------|---------|
| 3/1/21 | 5/3/21 |
| 3/1/21 | 5/14/21 |



sPHENIX IR Installation Schedule



RHIC Run FY22
11/15/21 to 4/3/22

RHIC Run FY23
Model (Jan to June)

sPHENIX component design, procure and install status

For AH and IR work through June 2022



| | Design and Integration | Procure/Fab Outside BNL | Fab and Installation at BNL |
|----------------------------------|--|---|--|
| 1008 AH floor and track upgrades | Complete | Complete | Complete |
| Cradle-base | Complete | Complete | Complete |
| Outer HCAL | Complete | Complete | oHCAL BNL factory complete Sector 1-13 AH install started, finish Aug-Sept Sector 14-32 after LSRs |
| Magnet AH landing | Complete | Babar magnet at bldg. 912 Magnet supports at BNL shop and Streck's, Due by end of July | AH install after oHCAL sector 1-13 |
| Large Support Rings | Complete | Machining at Streck's Due by mid Sept | AH install after magnet landed |
| Inner HCAL | Sectors and Barrel: Complete Install Tools: ½ complete, ½ in final design | Sectors and Barrel: Complete Install Tools: Reqs placed week of 7/5 | iHCAL sector, barrel factory: Aug 2021 iHCAL AH installation: ~Jan 2022 + oHCAL complete |
| EMCAL | Complete | Sector 28 of 64 complete EMCAL install tool fab at SBU, Fall 2021 | AH install start ~Feb 2022 + iHCAL complete Will have plenty of EMCAL sectors to get started |
| Carriage and platforms | Complete | Contract with Streck's Superstructure by mid-Nov 2021 Balance by mid-Dec 2021 | Install upper platform columns mid-Dec 2022 Complete in parallel with AH calorimeter installs |
| Pole tip doors | Complete | Contract with Streck's Delivery by mid-Jan 2022 | Install before upper platform ~ Feb-March 2022 |

sPHENIX component design, procure and install status

For AH and IR work through June 2022



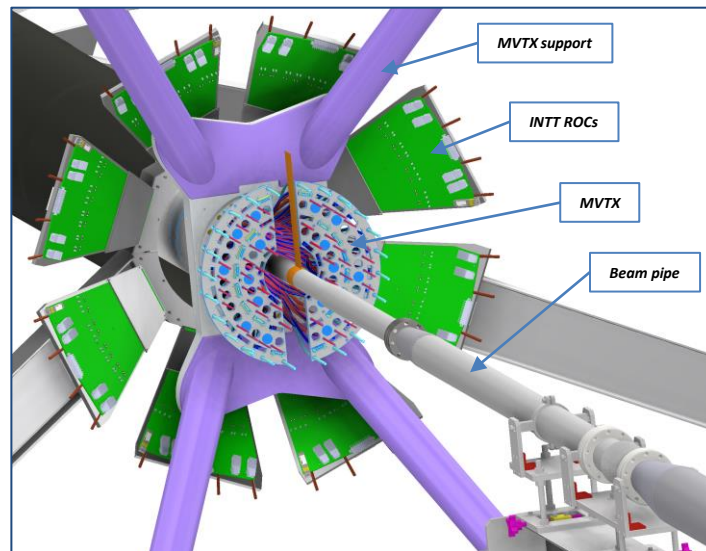
| | Design and Integration | Procure/Fab Outside BNL | Fab and Installation at BNL |
|----------------------------------|---|---|---|
| 1008 IR floor and track upgrades | Complete | Complete In talks with contractor for start up | Start late July 2021 |
| Magnet cryo and power | Complete | Complete | Cryo infrastructure: July 2021 Magnet connect and test: April 2022 |
| Magnet mapping | Ongoing discussions with CERN team FDR in Fall of 2021 | Working on contract to fund CERN team | Summer 2022 |

- All sPHENIX component design and the integration of components is thoroughly reviewed. There are design reviews to verify technical performance, ESRC reviews to vet safety aspects of installation and operations, and procurement reviews to check purchasing documentation and aspects of QA.
- sPHENIX uses INDICO, AutoDesk Vault, and other sPHENIX Sharepoint sites to store all design and review documentation.

- At this point in the project, we are primarily using detailed 3D models to manage mechanical interfaces and integration. All of the detector designs are complete, and most interface or integration issues pertain to installation planning and infrastructure design.
- Large scale integration and installation mockups are being used to finalize design and to practice and identify clashes or other issues.

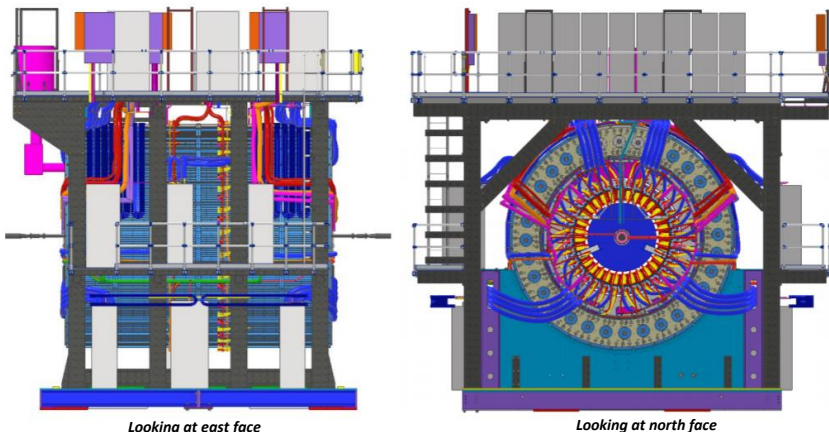


A full-scale mockup of the installation of oHCAL sector 1-3 was constructed in building 912. sPHENIX technicians and the CA-D rigging team practiced oHCAL installation and identified several hardware and process improvements that will be implemented on the full sPHENIX build. This also tested the critical interface between the cradle-base and the oHCAL sectors.

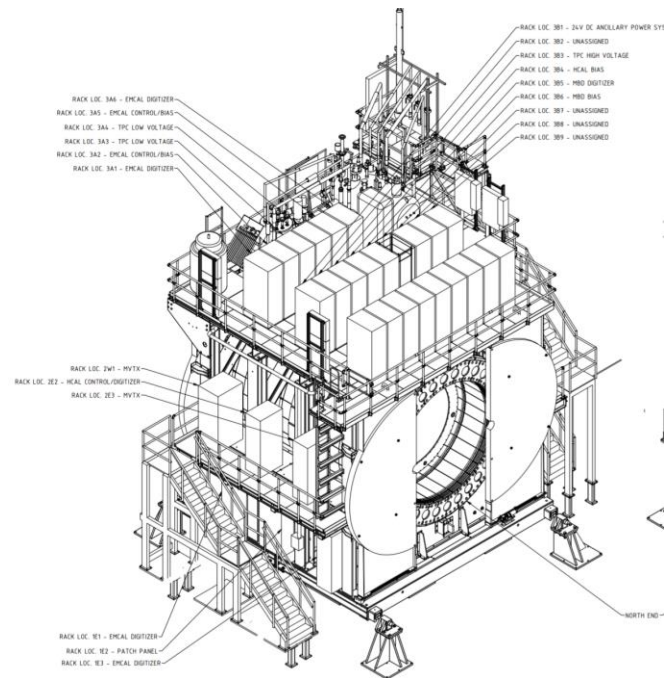


This is a view of the INTT-MVTX-Beam Pipe integration 3D CAD model. The MVTX team is building a full-scale mockup of this assembly at the MIT-Bates facility to identify integration, maintenance and installation issues. The 3D CAD models are very detailed but there is no substitute to hands-on experience. BNL is providing 3D printed parts for the INTT system for this mockup.

- The infrastructure team uses ICD-42 to manage on-carriage services: racks, cabling and power.
- Detailed 3D CAD models are used for cable routing and cable tray design, rack placement and the general integration of on-carriage infrastructure.



The sPHENIX detector is very compact and there are many cables and pipes to package in limited space. Cable routing design has been a major effort for the infrastructure team. The 3D CAD model was sufficiently detailed and reviewed to use as the basis for the large calorimetry cabling procurement. The views above show oHCAL, iHCAL, and EMCAL cables.



ICD-42 and connected drawings are used to manage all aspects of sPHENIX on-carriage infrastructure. This drawing shows the map of racks looking at the East and North ends of sPHENIX.

- The primary sPHENIX detector fabrication and construction hazards are heavy lifts, elevated work, and ergonomics.
- Safety is a key topic at all design reviews and there are an ongoing series of ESRC reviews for installation and detector operation.
- All installation work and lift engineering is planned following BNL SBMS guidelines
- The sPHENIX technicians and CA-D riggers, surveyors and technicians are a very experienced team. Everyone working in the AH and IR require training depending on their roles.
- BNL COVID guidelines are followed in the building 912 “factories” and in the sPHENIX building 1008 construction areas.
- Safety is everyone’s responsibility. As the sPHENIX construction picks up steam there will be groups needing access to the AH and IR for various purposes (assembly, testing, infrastructure, etc...). All work is planned and coordinated through the Thursday 2 PM meeting and other side meetings and discussions.

Some things we are keeping an eye on

- **Continued management of human resources.** For example, each oHCAL sector install requires 4-5 sPHENIX technicians and CA-D riggers, support from CA-D Survey, and support from the oHCAL physics team. sPHENIX has gotten very good support and we want to make sure this continues as we move into the long RHIC complex outage. Through the CA-D liaison engineer we provide a 2-week look ahead schedule to help plan resources allocation.
- **Following BNL COVID guidelines and the impact of COVID on the construction schedule.** sPHENIX is working closely with NPP management to track total allotted head count and visitors. BNL COVID hygiene rules are followed. The ability of the CERN-based magnet mapping team to BNL travel for magnet mapping in June of 2022 will be closely watched. A decision will be made by the end of December 2021 whether to start building and training a BNL-based magnet mapping team.
- **Completion of design and start of procurement of components for the next construction steps.** There is engineering design work to complete for the iHCAL installation, TPC installation, the tightly integrated installation of the INTT, MVTX and Beam Pipe, and finalizing the design of on-carriage infrastructure routing and installation. As the sPHENIX core team is splitting time between field construction duties and desk-based design work, we are relying on continued engineering support from ATRO, Magnet Division and CA-D.

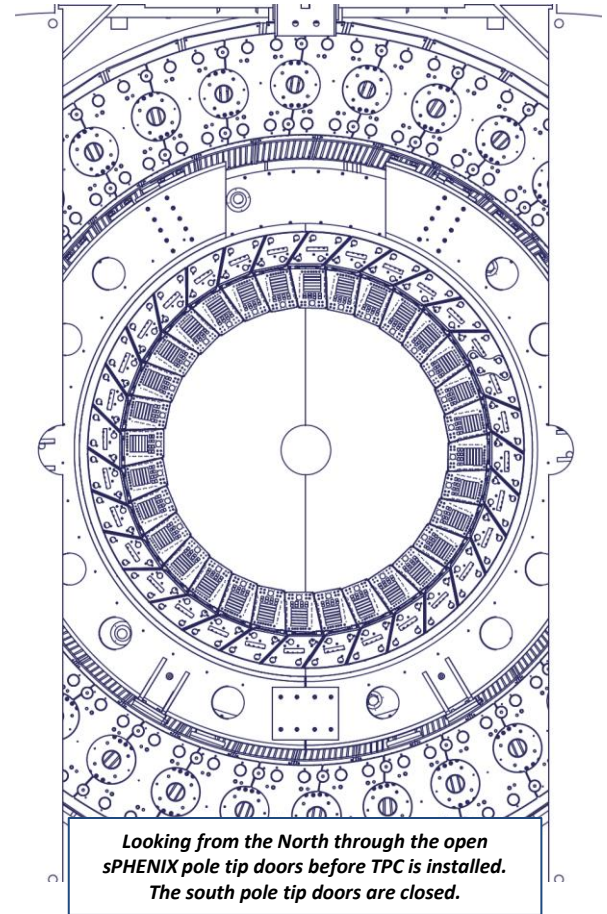
sPHENIX integration and installation



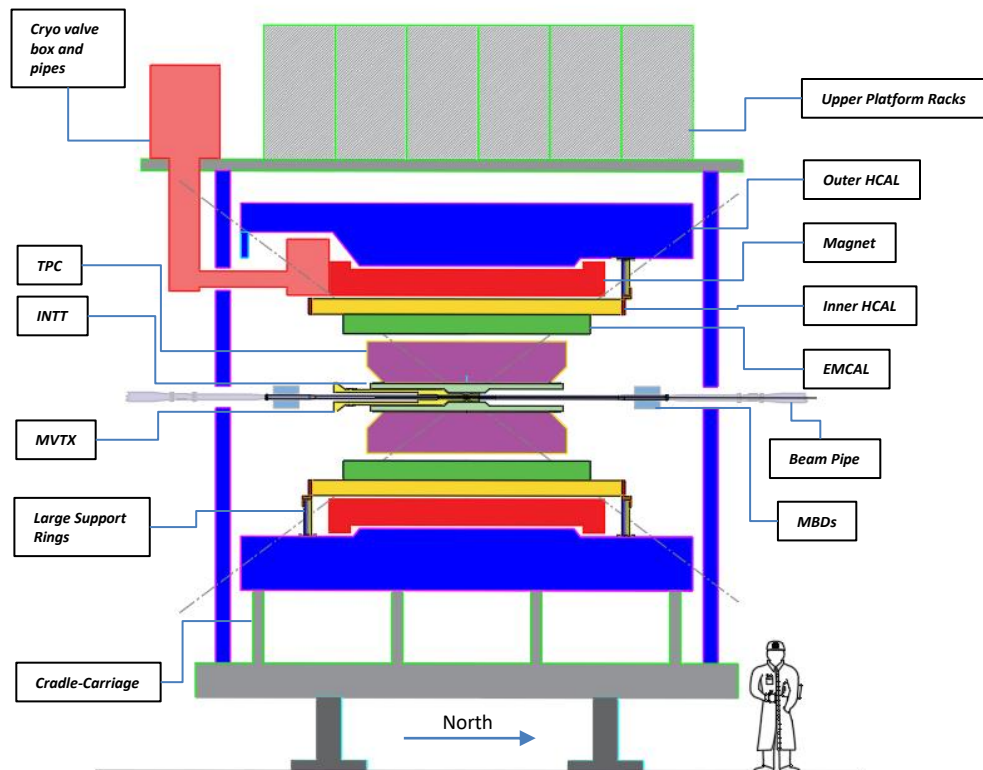
| MIE Charge Question | Integration and Installation Tie In |
|---|---|
| <p>Project scope: Is the project executing its technical baseline in a manner to deliver the science? Is the fabrication progress appropriate for this stage of the project? Are all interfaces properly understood?</p> | <p>Yes, all assembly interfaces are well understood. Structural analysis and design is complete for all sPHENIX components and assembly steps for work during CY 2021. Design reviews for all of these components included focus on assembly enabling interfaces and structural performance of the interfaces. <i>There are limits to the CAD model details and there is always some field fit up and adjustment needed.</i></p> |
| <p>Cost and Schedule: Will the project's remaining cost and schedule resources be sufficient to achieve PD-4? Is contingency usage appropriate for this stage of the project? Is the project critical path clearly identified and understood?</p> | <p>For project management and MIE review purposes, the sPHENIX MIE schedule and critical path analysis is separate from the overall sPHENIX 2.X construction schedule. All schedule links between the 1.X MIE components and the 2.X schedule have been set up and reviewed. The RHIC experimental schedule, 1008 infrastructure work, and construction engineering deliverables are all also linked into the schedule.</p> |
| <p>Management: Is the project being properly managed at this stage? Are the risks properly identified and managed and are appropriate mitigation strategies in place? Are the procurements being properly managed?</p> | <p>Yes, integration and installation aspects of the project are well managed. Regular large and small group integration meetings are held as needed and detailed 3D CAD models are used to periodically check interfaces and installation features. 1.X and 2.X procurements (and all the supporting engineering) have been managed to support the overall construction schedule.</p> |
| <p>Environment, Safety & Health and Quality Assurance (ES&H/QA): Are the ES&H/QA requirements being properly addressed given the project's current stage of development?</p> | <p>Yes. In the sectors factories, detector lab areas, and in the 1008 AH ES&H/QA requirements are addressed. SBMS-based guidance for work safety and work planning have been followed. Safety and QA representatives are included in design reviews, drawing and SOW approvals, work planning meetings, and other aspects of the construction project.</p> |
| <p>Preparation for installation: Is the hand off to installation properly planned? Are the tests of equipment and interfaces properly understood?</p> | <p>Yes, the hand off to installation is properly planned. All schedule links between the 1.X MIE components and the 2.X schedule have been set up and reviewed. The RHIC experimental schedule, 1008 infrastructure work, and construction engineering deliverables are all also linked into the schedule.</p> |
| <p>COVID-19: Are the cost/schedule impacts from COVID-19 on the sPHENIX MIE cost and schedule understood and being properly assessed and managed?</p> | <p>To date, COVID restrictions have not impacted the availability of components or personnel for sPHENIX installation. There could be an issue with the CERN-based magnet mapping team travelling to BNL Summer 2022. We are tracking this and will make adjustment by December 2021 if we think there is a risk.</p> |
| <p>Recommendations: Has the project responded appropriately to previous review recommendations?</p> | <p>The closeout reports from the previous MIR reviews discuss impacts on installation due to delays in detector production. There are no specific recommendations addressed to integration or installation management.</p> |

Summary

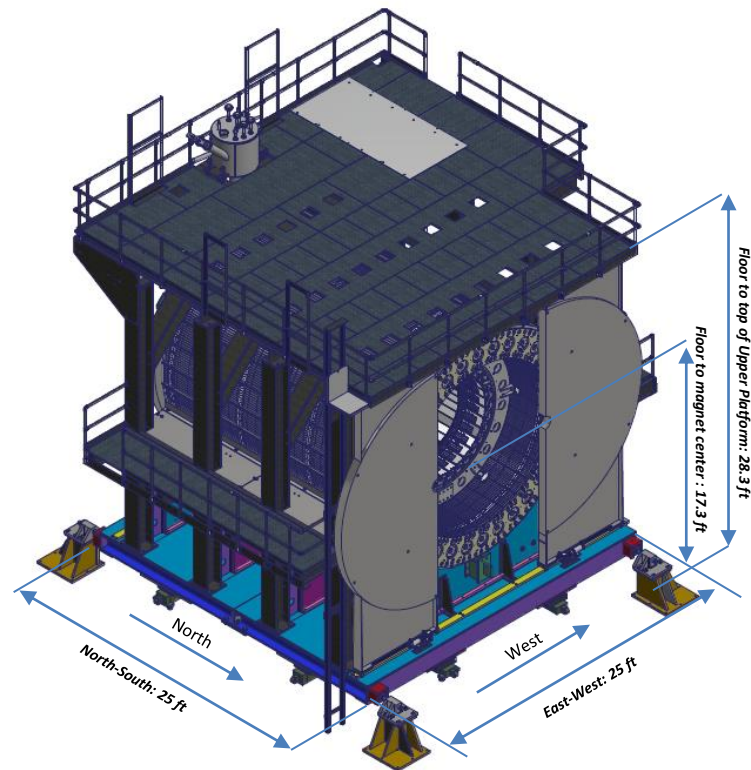
- sPHENIX construction is underway. The cradle-base is sitting on the upgraded AH tracks and oHCAL sector #1 is precisely positioned and secured. oHCAL construction will resume at the end of July once the 1008 shield wall is removed and the cradle-base is set back in the construction position.
- All components needed to build sPHENIX through the end of 2021 are in hand (base, oHCAL sectors, magnet) or in late stages of fabrication and will be delivered weeks before needed (Large Support Rings, Carriage superstructure and Pole Tip Doors).
- sPHENIX is getting timely personnel support from CA-D, ATRO and Magnet Division for construction work and to complete the remaining design engineering tasks.
- Safety is a priority for the sPHENIX project. Each major installation step has a thoroughly reviewed and approved work planning package and rigging plan. COVID has had minimal impact on sPHENIX construction because vendors worked through the pandemic and sPHENIX technicians have been on-site under BNL headcount guidelines.



Back Up



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.

Cumulative Weight %-complete

| | Weight (tons) | Cumulative (tons) | % of Total |
|---|------------------|-------------------|------------|
| Cradle-base halves | 2 x 36.5 + eqipt | 73 | 8.1 |
| Cradle-base other parts | 60 | 133 | 14.8 |
| <hr style="border-top: 1px dashed red;"/> | | | |
| oHCAL sector 1-13 | 13 x 16 | 341 | 37.9 |
| Babar Magnet | 14 | 355 | 39.4 |
| Large Support Rings | 4 | 359 | 39.9 |
| oHCAL sector 14-32 | 19 x 16 | 663 | 73.7 |
| iHCAL barrel | 18 | 681 | 75.7 |
| EMCAL sectors | 64 x .5 | 713 | 79.2 |
| Carriage and platforms | 72 (various) | 785 | 87.2 |
| Pole Tip Doors | 4 x 23 | 877 | 97.4 |
| <hr style="border-top: 1px dashed red;"/> | | | |
| TPC, INTT, MVTX, MBD, Cryo Eqpt, Racks, Cables, Pipes, etc... | 23 | 900 | 100 |

You are here

When the oHCAL barrel is built the project will be 73.7% complete by weight.

sPHENIX will be at 877 tons (97.4% of total weight) when we roll into the IR.

Move to
IR

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 place and essential cryogenics work is underway

sPHENIX Installation Risks: Events

→ Refer to the sPHENIX 2.X project risk register for risk probability and impacts.

| Risk Title | Risk Statement | Risk Notes | What have we done to mitigate impacts ? |
|-----------------------|--|---|---|
| Key Equipment Failure | If key equipment required for sPHENIX installation fails there will be cost and schedule delays. | Key equipment includes the 40-ton AH crane, hydraulic devices for moving sPHENIX on the AH and IR rails and other key equipment. | <ul style="list-style-type: none"> Regular eqpt test and maintenance |
| Safety Incident | If there is a serious safety incident that harms a person working on the sPHENIX construction there will be cost and schedule impacts. | There could be delays due to reviews and revisions of procedures, rework or repair to unsafe equipment or a stand down for training. There are also personnel replacement impacts. | <ul style="list-style-type: none"> Design Reviews Working with Safety org Follow BNL and CA-D procedures Prototypes to test fit |
| Component damage | If a sPHENIX component or key infrastructure item is damaged during construction or installation then there will be cost and schedule impacts. | A damaged component may require rework and repair activities or may require some engineering analysis to determine safety and performance impacts. | |
| Component rework | If, during construction or installation, it is found that a sPHENIX component or key infrastructure item needs to be reworked there will be cost and schedule impacts. | In this case rework is for a part that does not fit or if it is found that some design feature needed for installation was not included. This is not rework for damage. This could be a simple tech activity up to requiring a design review and a significant design change. | |

sPHENIX Installation Risks: Uncertainty



→ Risk handled in the project RLS through estimate uncertainty

| Risk Title | Risk Statement | Risk Notes | What have we done to mitigate impacts ? |
|-----------------------|--|---|--|
| Infrastructure delay | If infrastructure improvements or new infrastructure in building 1008 that are predecessors for sPHENIX construction to start are delayed there will be cost and schedule impacts. | This infrastructure includes the AH and IR rails, cryo lines for the Babar magnet and other key infrastructure. | <ul style="list-style-type: none"> MOAs Complete design ASAP Push critical procurements |
| Component delay | If a component of the sPHENIX detector is not delivered to building 1008 and ready for installation there will be cost and schedule impacts. | | <ul style="list-style-type: none"> Push critical procurements Prototypes to test fit |
| Personnel unavailable | If key personnel are not available as needed during sPHENIX construction there will be cost and schedule impacts. Key personnel include physics or CA-D managers, engineers, technicians, safety and QC coverage and other individuals or teams needed to accomplish the work at hand. | Key personnel include physics or CA-D managers, engineers, technicians, safety and QC coverage and other individuals or teams needed to accomplish the work at hand. This risk is also realized if there is work scheduled during lab holidays or heavy vacation periods. | <ul style="list-style-type: none"> MOAs and University relations Hiring within Physics |

