# sPHENIX Director's Review
# Project Overview

Edward O'Brien

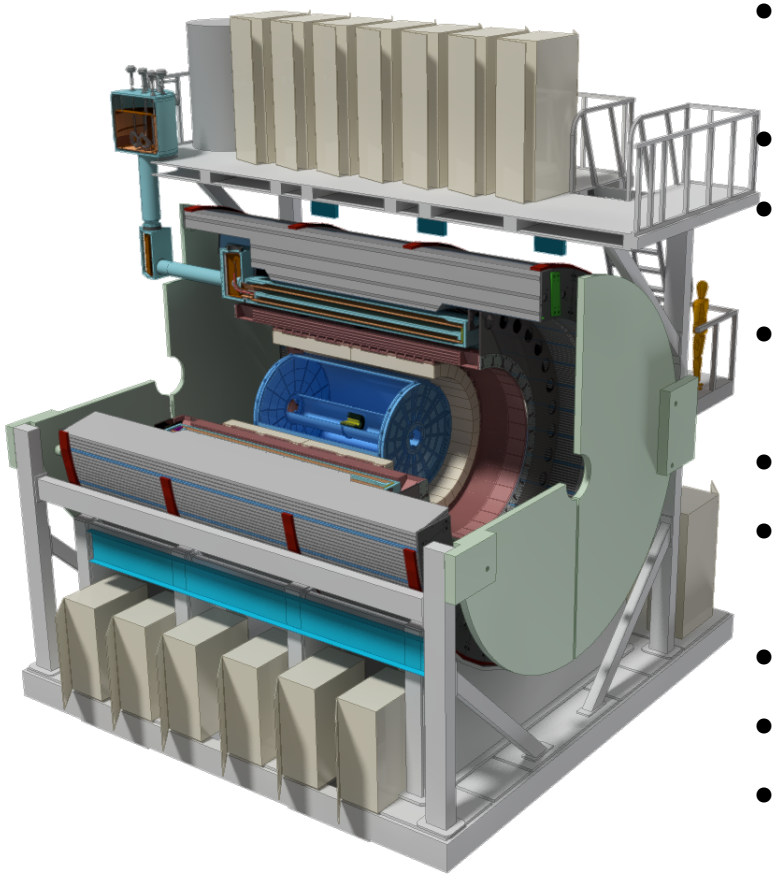
August 2-4, 2017

BNL

# What is sPHENIX ?

- **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 Tracker, full EM and Hadronic calorimeter coverage at $|\eta| < 1.1$, and a 1.5 T solenoidal magnetic field.**
- **It will utilize much of the infrastructure already existing in the PHENIX detector complex and the BaBar SC-magnet. The Min Bias Trigger Detector is the reused PHENIX Beam Beam Counter with upgraded electronics.**
- **A bottom-up resource-loaded project plan has sPHENIX assembled, commissioned and ready to take data in January 2023 based on the DOE-ONP guidance for the Critical Decision from earlier this year.**

# sPHENIX Conceptual Design



- Uniform fiducial acceptance $-1<\eta<1$ and $0<\phi<2\pi$
- Superconducting solenoid enabling high resolution tracking
- Hadronic calorimeter doubling as flux return
- Compact electromagnetic calorimeter to allowing fine segmentation at a small radius
- Solid state photodetectors that work in a magnetic field, have low cost, do not require high voltage
- Common readout electronics in the calorimeters
- High rate 15 kHz in AA allows for large unbiased MB data sample
- Utilization of existing PHENIX exp Infrastructure
- Compact TPC 250 mm hit res & continuous readout
- 4 Intermediate silicon strip tracking layers (Japanese funds)

Not part of this review →

- 3 layer – $2\pi$ MAPS-based vertex det (DOE-Upgrade)

**Most Detector components are at an advanced state of R&D**

# The Three Parts of sPHENIX

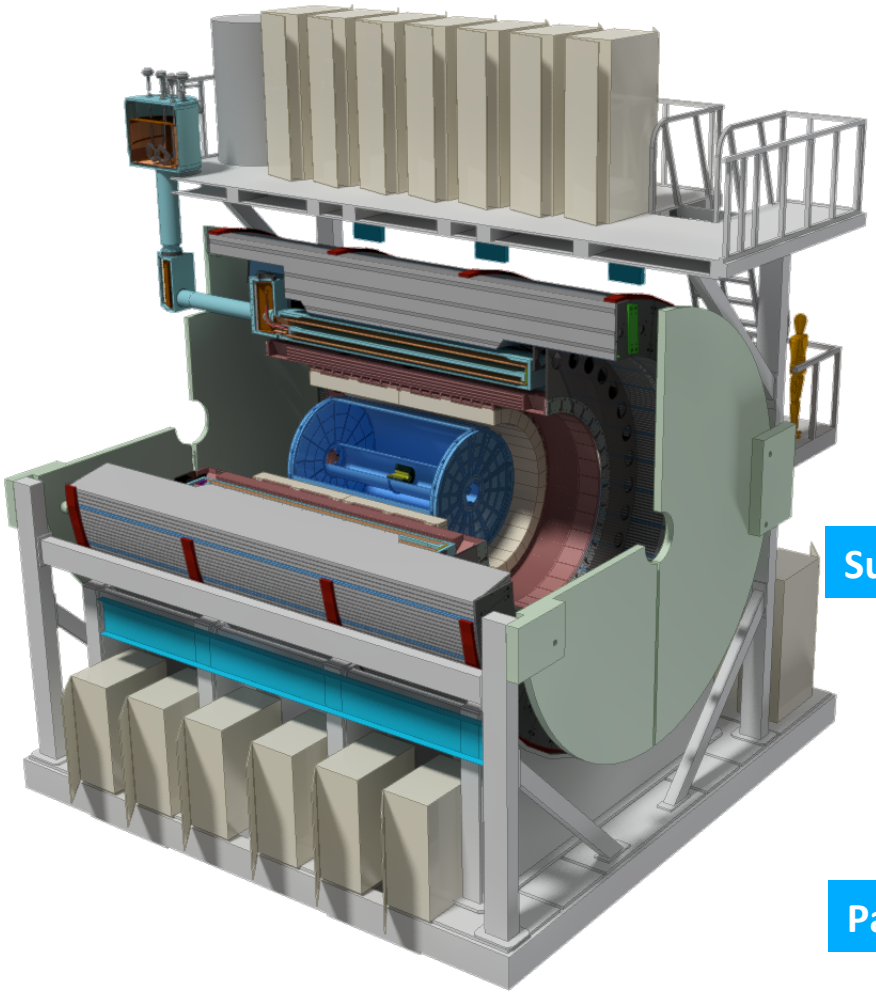
| | |
|---|---|
| **MIE Cost range is $29-35M** | **DOE funded & Managed** |
| **Upgrade Support is ~$20M** | **BNL Funded & Managed** |
| **Infrastructure/Facility Upgrade ~$20M** | **BNL Funded & Managed** |

A. **sPHENIX MIE** Upgrade covering the detector (Project Management, TPC, EMCal, HCal, Calorimeter Electronics, DAQ/Trigger, Min Bias Detector). Dominated by M&S costs. The MIE carries labor for Project Management and ~$1M in paid University labor for building things.

B. **Upgrade Support** is 100% BNL labor that supports the sPHENIX MIE upgrade. Primarily the Phys Dept PHENIX/sPHENIX technical support group augmented by CAD, Magnet Div and Instrumentation Div.

C. **Infrastructure and Facility Upgrade** of the 1008 complex . Combination of M&S and Labor. Purpose is the upgrade of 1008 to modern standards. Enables cryo operations in 1008 and provides a facility optimized for the operation of a modern detector.

# WBS of sPHENIX MIE & Support Effort



## MIE

| 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 |

**Support Activities managed by the sPHENIX Project team**

| WBS | Infrastructure & Facility Upgrade |
|---|---|
| 1.8 | SC-Magnet |
| 1.9 | Infrastructure |
| 1.10 | Installation-Integration |

**Parallel Activities funded from other sources**

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

# sPHENIX Schedule

| | |
|---|---|
| sPHENIX passes DOE Science Review | Apr 2015 |
| CD-0 Mission Need Approved | Sep 2016 |
| BNL Director's pre CD-1 Review | Sep 2017 |
| OPA-CD-1/CD-3a Review | Spring 2018 |
| CD-1/CD-3a authorization (?) | Dec 2018 |
| Fabrication (orders) of long lead time components begins | Dec 2018 |
| All Preproduction R&D and Design complete | Spring 2019 |
| OPA- CD-2/CD-3b review | Spring 2019 |
| CD-2/CD-3b authorization (?) | Aug 2019 |
| All fabrication (orders) begin | Aug 2019 |
| sPHENIX installation begins in 1008 Facility | Apr 2021 |
| MIE deliverables complete | Dec 2021 |
| sPHENIX Installed, cabled, ready to commission | Jul 2022 |
| Initial commissioning complete | Sep 2022 |
| First RHIC beam for sPHENIX | Jan 2023 |
| CD-4 Approval | Jan 2024 |

**The Resource-loaded Schedule contains 6 months of float to Jan 2023 first beam @ RHIC**

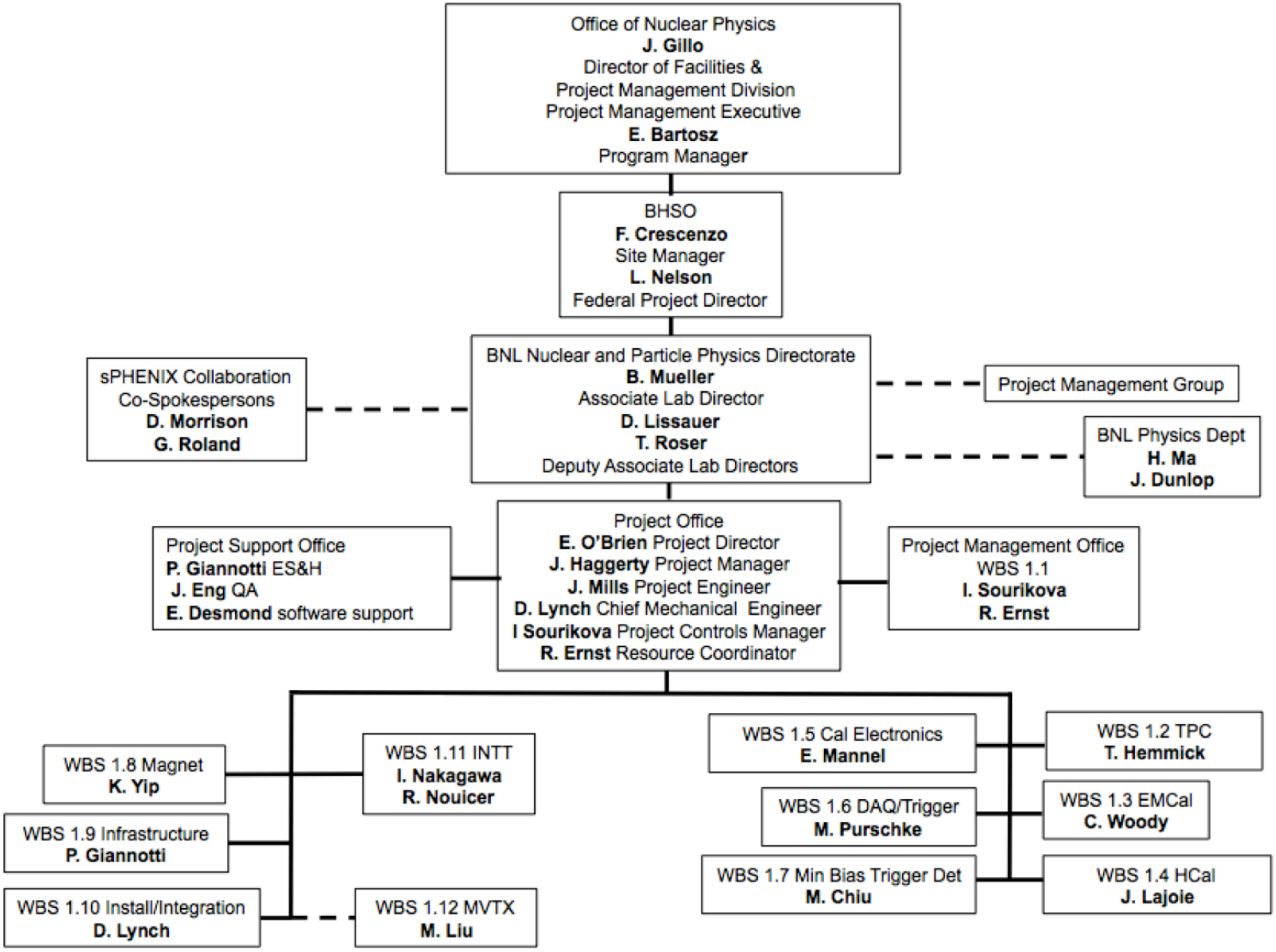
**The MIE has 24 months of float to CD-4**

# CD-1 Documents Available to the Committee

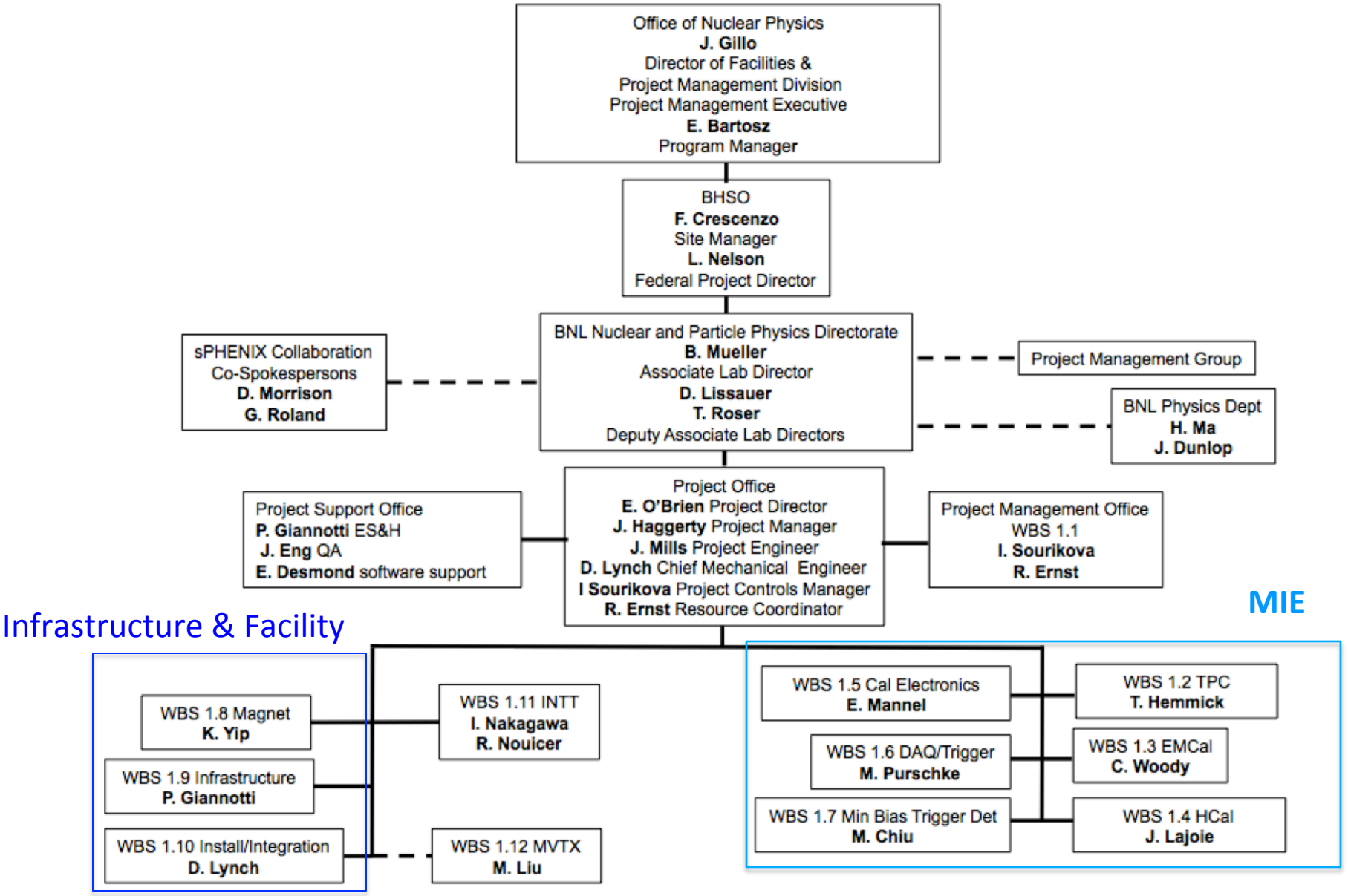
1. **Project Team Organization**
2. **WBS (WBS Dictionary)**
3. **Basis of Estimate documents**
4. **Contingency Risk/Analysis**
5. **Project Schedule**
6. **Critical Milestones**
7. **Proposed Funding Profile**
8. **Proposed Labor Profile**
9. **Preliminary Hazard Analysis Report**
10. **NEPA form**
11. **Integrated Safety Management Plan**
12. **Conceptual Design/Conceptual Design Report-**
13. **Acquisition Strategy**
14. **Preliminary Project Execution Plan**
15. **Preliminary Risk Assessment and Risk Registry**
16. **Security Vulnerability Assessments (Equipment protection & cyber security)**
17. **Alternate Analysis**

# Project Organization

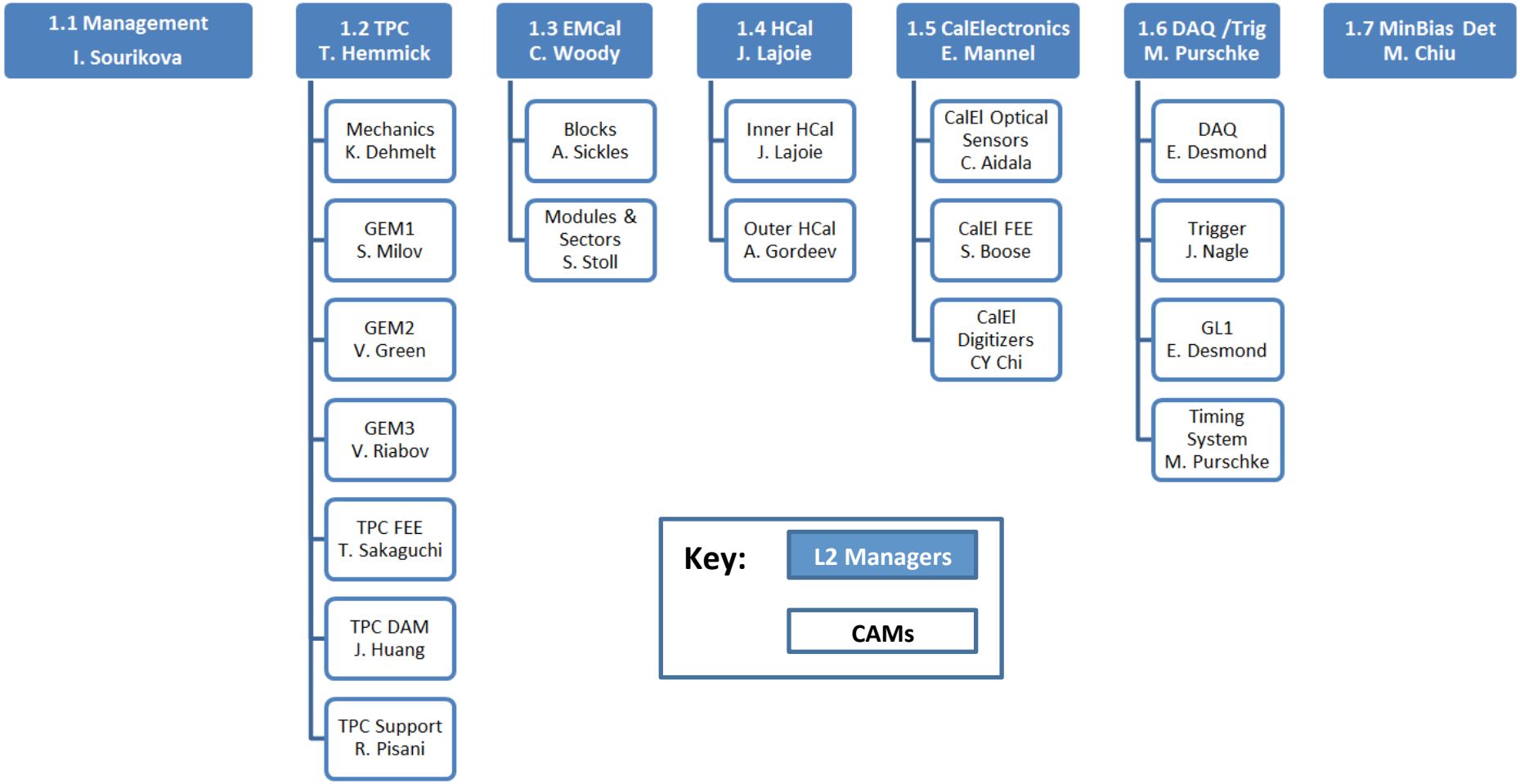
https://docdb.sphenix.bnl.gov/0001/000104/001/sPHENIX-Bios.docx.pdf



# Project Organization



# L2 and CAM Structure of MIE



# L2 Managers & Control Account Managers

## L2 Managers:

| | |
|---|---|
| **1.1 Project Management** | **Irina Sourikova(BNL-Project Controls)** |
| **1.2 TPC** | **Tom Hemmick (SBU)** |
| **1.3 EMCal** | **Craig Woody (BNL)** |
| **1.4 HCal** | **John Lajoie (ISU)** |
| **1.5 Calorimeter Electronics** | **Eric Mannel (BNL)** |
| **1.6 DAQ/Trigger** | **Martin Purschke (BNL)** |
| **1.7 Min Bias Trigger Detector** | **Mickey Chiu (BNL)** |

## Control Account Managers

| | |
|---|---|
| Project Managmt | Irina Sourikova (BNL) |
| TPC Detector | Klaus Dehmelt (SBU) |
| GEM r1 | Sasha Milov (WIS) |
| GEM r2 | Vicki Greene (Vandblt) |
| GEM r3 | Victor Riabov (PNPI) |
| TPC FEE | Takao Sakaguchi (BNL) |
| TPC DAM | Jin Huang (BNL) |
| EMC Blocks | Anne Sickles (UIUC) |
| EMC Module/Sector | Sean Stoll (BNL) |

| | |
|---|---|
| Inner HCal | John Lajoie (ISU) |
| Outer HCal | Anatoli Gordeev (BNL) |
| CalE SiPMs | Christine Aidala (UM) |
| CalE Preamps | Steve Boose (BNL) |
| CalE Digitizer | CY Chi (Columbia) |
| DAQ | Ed Desmond (BNL) |
| Trigger | J. Nagle(UColorado) |
| Timing Sys | TBD (If necessary) |
| MB Trig Det | Mickey Chiu (BNL) |

# Resource-Loaded Schedule Status

**We are finishing a bottom-up revision to the Resource-loaded schedule**

- **6 month effort of ~40 - 50 people.**
- **1800+ activities over 11 WBS L2 categories. All in MS-Project**
- **The MIE Activities were integrated with the Magnet, Infrastructure, Installation/ integration.**
- **Merged the INTT with the rest of the project files**
- **Consultant migrating the files to P6 in process. No review yet by L2's or CAMs. Ready for primetime early Sept**

## RLS and BOE Procedure:

- **BOE of Cost and Duration based on Vendor bids or quotes, catalog prices, engineering estimates or previous experience**
- **L2s/CAMs Bottom-up contingency based on uncertainty(risk) table**
- **Use BNL Labor bands, BNL Extraordinary OH rates, university rates where applicable.**
- **Non-BNL labor availability estimates came from collaborating institutions**
- **No RFP's on MIE. 1 RFP in SC-Magnet (cryo bypass)**
- **The CERN GEM order involves only vendor that doesn't take payment in $.**
  - **No significant foreign exchange issues.**
- **Labor resources not available from BNL Phys Dept will come from CAD, Mag Div, Instrumentation Div, or collaborating Institutions**

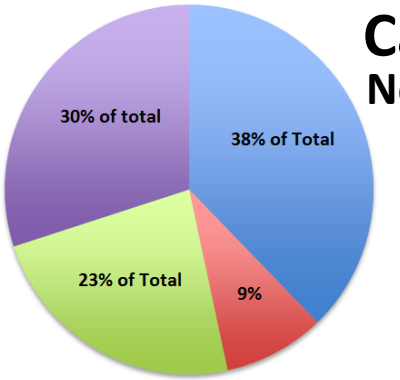
# sPHENIX BOE Contingency Guidelines

Materials Bottom-Up Contingency
Uniformly Graded Approach to Risk Across All Subsystems

There is a similar table for Labor contingency estimates

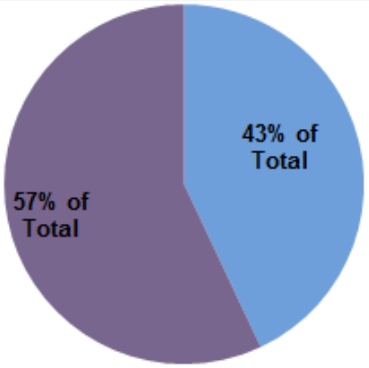
| Code | Type of Estimate | Contingency % | Description |
|---|---|---|---|
| M1 | Existing Purchase order | 0% | Items have been completed or obligated. (Note: Contact Change Orders are considered a Risk and should not be included ) |
| M2 | Procurement for LOE/ Oversight work | 0%–20% | M&S items such as travel, software purchases and upgrades, computers, etc. estimated to support LOE efforts and other work activities. |
| M3 | Advanced | 10%–25% | Items for which there is a catalog price or recent vendor quote based on a completed or nearly completed design or an existing design with little or no modifications and for which the costs are documented. |
| M4 | Preliminary | 25%–40% | Items that can be readily estimated from a reasonably detailed but not completed design; items adapted from existing designs but with moderate modifications, which have documented costs from past projects. A recent vendor survey (e.g., budgetary quote, vendor RFI response) based on a preliminary design belongs here. |
| M5 | Conceptual | 40%–60% | Items with a documented conceptual level of design; items adapted from existing designs but with extensive modifications, which have documented costs from past projects. |
| M6 | Pre-conceptual – Common work | 60%–80% | Items that do not have a documented conceptual design, but do have documented costs from past projects. Use of this estimate type indicates little confidence in the estimate. Its use should be minimized when completing the final estimate. |
| M7 | Pre-conceptual – Uncommon work | 80%–100% | Items that do not have a documented conceptual design, and have no documented costs from past projects. Its use should be minimized when completing the final estimate. |
| M8 | Beyond state of the art | > 100% | Items that do not have a documented conceptual design, and have no documented costs from past projects. Technical requirements are beyond the state of the art. |

# Basis of Estimate



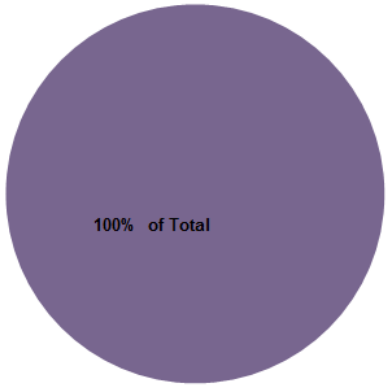

## Calorimeter Electronics
**Net contingency 30%**

- Engineering estimate - 40%
- Engineering estimate - 30%
- Engineering estimate - 25%
- Quotes - 20%



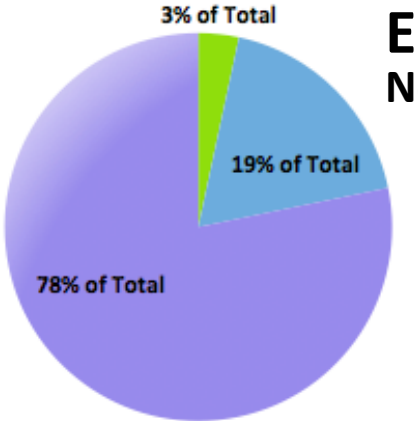

- Engineering estimate 40%
- Quotes 20%

## HCal
**Net Contingency 29%**



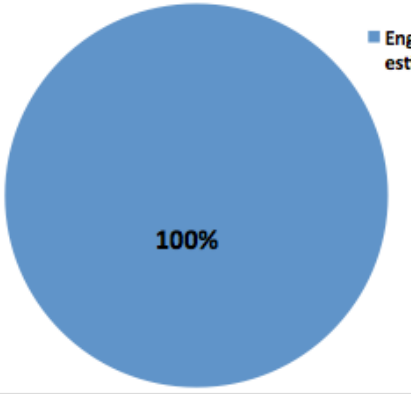

- Quotes - 20%

## DAQ/Trigger
**Net contingency 20%**



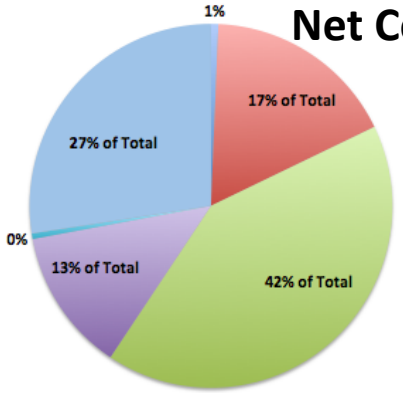

## EMCal
**Net Contingency 25%**

- catalog/web quote 23%
- engineering estim. 32%
- quote 23%




- Engineering estimate 40%

## MBD
**Net Contingency 40%**

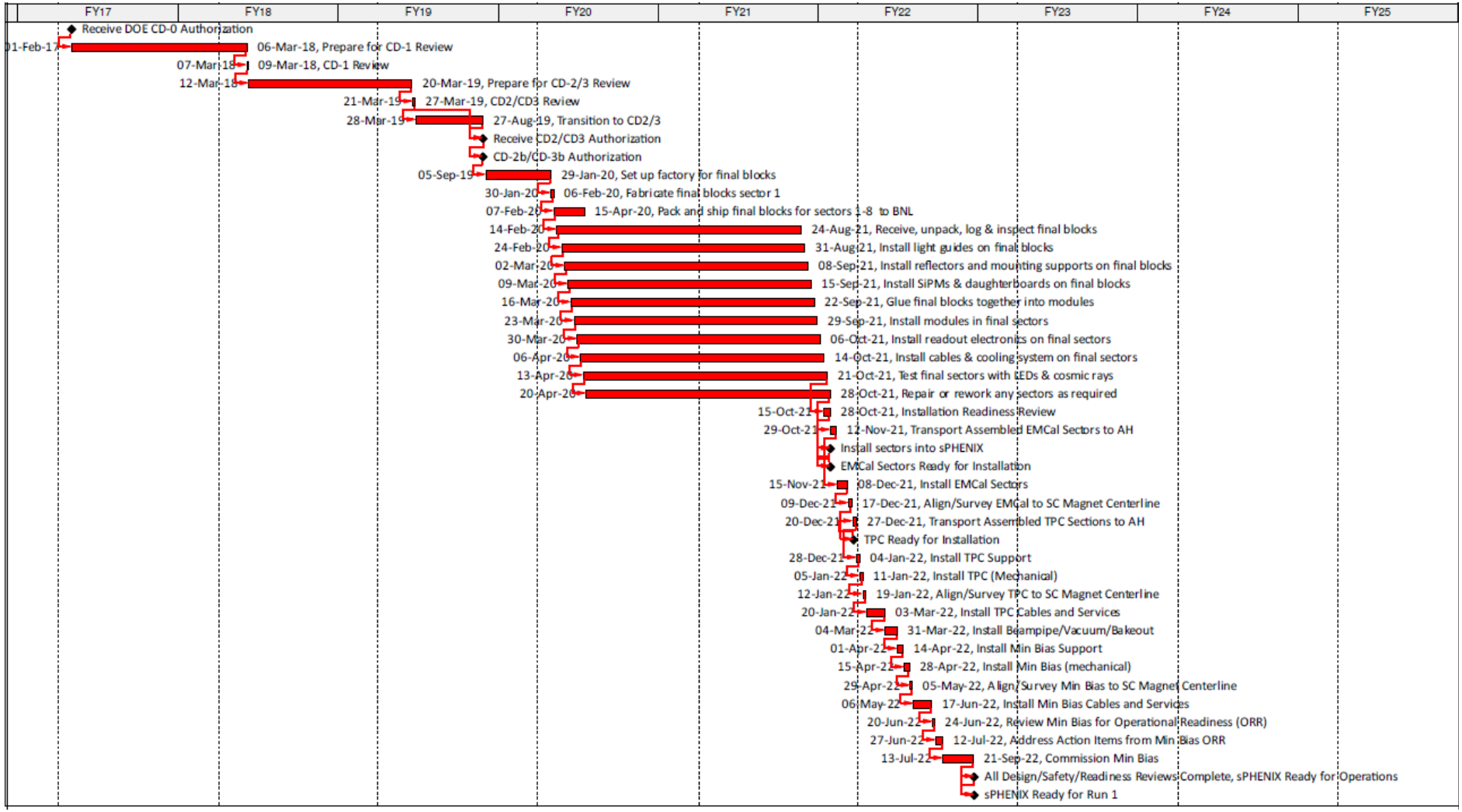



## TPC
**Net Contingency 25%**

- Pending Delivery
- Quote 15%
- Quote 20%
- Older quote 25%
- Engineering Estimate 25%
- Engineering Estimate 40%

# sPHENIX Critical Path Calculated in P6

**sPHENIX MS-Project and P6 give essentially the same critical path**



# Major Project Milestones for L2 Subsystems

| WBS | Project Milestone of LEVEL-2 subsystems | Scheduled Dates |
|---|---|---|
| 1.2.1 | TPC available for installation | 11/2020 |
| 1.2.2 | Quad GEM Module Readiness review | 6/2019 |
| 1.2.2/3/4 | Quad GEM Module Production complete | 6/2020 |
| 1.2.5 | TPC FEE Production Readiness review | 5/2019 |
| 1.2.5 | TPC FEE Production complete | 7/2020 |
| 1.2.6 | TPC DAM Production Readiness review | 6/2019 |
| 1.2.6 | TPC DAM Production complete | 9/2020 |
| 1.3.2 | Block Production Readiness review | 1/2020 |
| 1.3.3 | Module and Sector Production Readiness review | 8/2019 |
| 1.3.4 | EMCal sectors complete, available for installation | 11/2021 |
| 1.4.2 | Procurement of IHCal mechanical structure complete | 4/2021 |
| 1.4.2 | Procurement of IHCal scintillating tiles complete | 10/2020 |
| 1.4.2 | Last sector IHCal available for installation | 6/2021 |
| 1.4.3 | Procurement of OHCal scintillating tiles complete | 3/2020 |
| 1.4.3 | First sector OHCal available for installation | 9/2020 |
| 1.4.3 | Last sector OHCal available for installation | 4/2021 |
| 1.5.1 | Optical Sensor Procurement Complete | 9/2020 |
| 1.5.2 | EMCal Fee Production Complete | 2/2021 |
| 1.5.2 | HCal Fee Production Complete | 10/2020 |
| 1.5.3 | Calorimeter Digitizer Production start | 8/2019 |
| 1.5.3 | Calorimeter Digitizer Production Complete | 10/2020 |
| 1.6 | DAQ Ready for Operation | 10/2021 |
| 1.7.3 | Receive Digitizers for Min Bias Det | 4/2020 |
| 1.7.4 | Min Bias Det available for installation | 12/2020 |

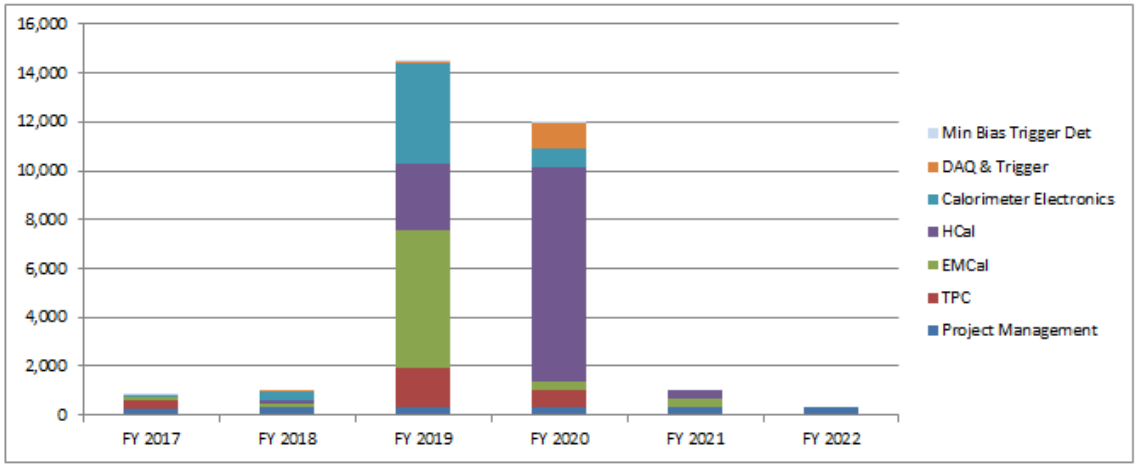
# The MIE Part of sPHENIX

**MIE Cost range is $29-35M** **DOE Funded & Managed**

- The full MIE scope exceeds the cost range by ~3.5 M AY$ (contingency included)
- All documents including the RLS, BOEs, labor profiles etc. assume the full scope
- We have two descope options that fall within the budget range but the detailed science impact has yet to be evaluated by the collaboration.
- The intention is to build the full scope by reducing costs through scrubbing and value engineering, while also pursuing additional funds from International and other sources.
- The Project is working with the collaboration and BNL to devise a plan to get back within the cost range.

# sPHENIX Cost Estimate – Full Scope

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



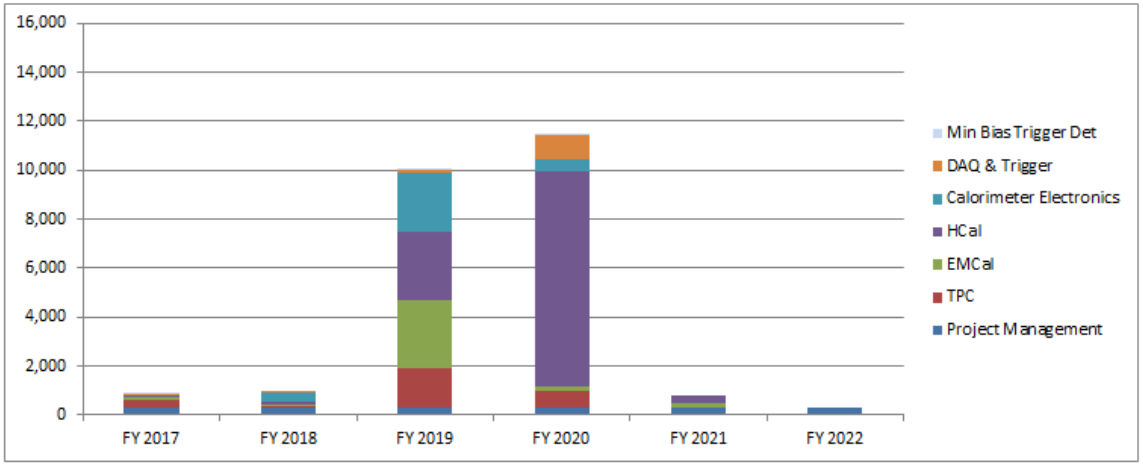

**Baseline Scenario**
**AY k$'s - with Extraordinary Construction Overhead Application**

| WBS | SYSTEM | FY 2017 | FY 2018 | FY 2019 | FY 2020 | FY 2021 | FY 2022 | Total |
|---|---|---|---|---|---|---|---|---|
| 1.1 | **Project Management** | 280 | 320 | 320 | 320 | 305 | 305 | 1,850 |
| 1.2 | **TPC** | 323 | 31 | 1,575 | 675 | 0 | | 2,604 |
| 1.3 | **EMCal** | 161 | 96 | 5665 | 396 | 380 | | 6,698 |
| 1.4 | **HCal** | 15 | 129 | 2,752 | 8,777 | 313 | | 11,986 |
| 1.5 | **Calorimeter Electronics** | 52 | 351 | 4,051 | 767 | 0 | | 5,221 |
| 1.6 | **DAQ & Trigger** | 19 | 32 | 114 | 1,035 | 0 | | 1,200 |
| 1.7 | **Min Bias Trigger Det** | 63 | 0 | 19 | 54 | 0 | | 136 |
| | Baseline Total | 913 | 959 | 14,496 | 12,024 | 998 | 305 | 29,695 |
| | MIE Contingency | 274 | 288 | 4,349 | 3,607 | 299 | 92 | 8,909 |
| | MIE Total | 1187 | 1247 | 18845 | 15631 | 1297 | 397 | 38604 |

| WBS | SYSTEM | Baseline | Contingency | Total |
|---|---|---|---|---|
| 1.1 | **Project Management** | 1,850 | 555 | 2,405 |
| 1.2 | **TPC** | 2,604 | 781 | 3,385 |
| 1.3 | **EMCal** | 6,698 | 2009 | 8,707 |
| 1.4 | **HCal** | 11,986 | 3596 | 15,582 |
| 1.5 | **Calorimeter Electronics** | 5,221 | 1566 | 6,787 |
| 1.6 | **DAQ & Trigger** | 1,200 | 360 | 1,560 |
| 1.7 | **Min Bias Trigger Det** | 136 | 41 | 177 |
| | MIE Totals | 29,695 | 8909 | 38,604 |

# sPHENIX Descope Scenario -1, 50% EMCal

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




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

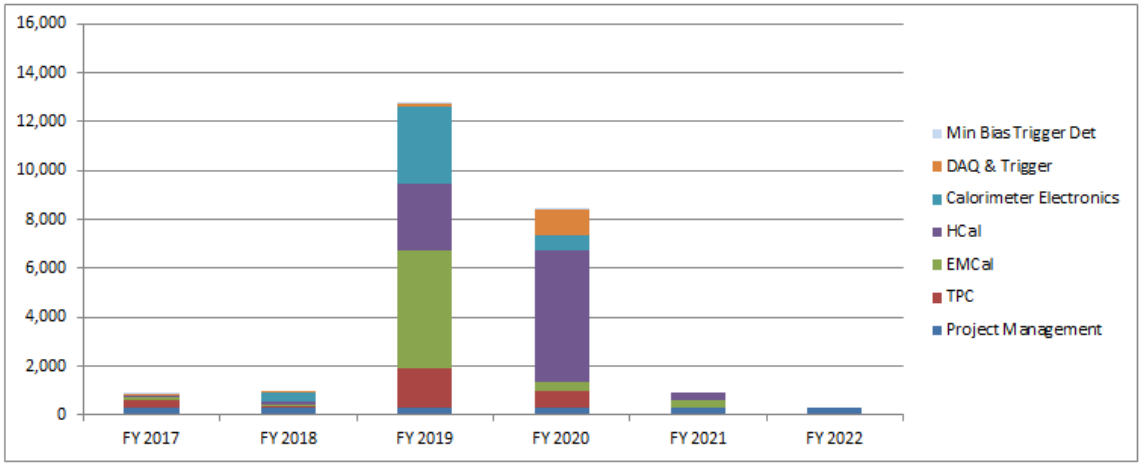
| WBS | SYSTEM | FY 2017 | FY 2018 | FY 2019 | FY 2020 | FY 2021 | FY 2022 | Total |
|---|---|---|---|---|---|---|---|---|
| 1.1 | **Project Management** | 280 | 320 | 320 | 320 | 305 | 305 | 1,850 |
| 1.2 | **TPC** | 323 | 31 | 1,575 | 675 | 0 | | 2,604 |
| 1.3 | **EMCal** | 161 | 96 | 2832.5 | 198 | 190 | | 3,478 |
| 1.4 | **HCal** | 15 | 129 | 2,752 | 8,777 | 313 | | 11,986 |
| 1.5 | **Calorimeter Electronics** | 52 | 351 | 2,431 | 460 | 0 | | 3,294 |
| 1.6 | **DAQ & Trigger** | 19 | 32 | 114 | 1,035 | 0 | | 1,200 |
| 1.7 | **Min Bias Trigger Det** | 63 | 0 | 19 | 54 | 0 | | 136 |
| | Baseline Total | 913 | 959 | 10,043 | 11,519 | 808 | 305 | 24,547 |
| | MIE Contingency | 274 | 288 | 3,013 | 3,456 | 242 | 92 | 7,364 |
| | MIE Total | 1187 | 1247 | 13056 | 14975 | 1050 | 397 | 31911 |

| WBS | SYSTEM | Baseline | Contingency | Total |
|---|---|---|---|---|
| 1.1 | **Project Management** | 1,850 | 555 | 2,405 |
| 1.2 | **TPC** | 2,604 | 781 | 3,385 |
| 1.3 | **EMCal** | 3,478 | 1043 | 4,521 |
| 1.4 | **HCal** | 11,986 | 3596 | 15,582 |
| 1.5 | **Calorimeter Electronics** | 3,294 | 988 | 4,282 |
| 1.6 | **DAQ & Trigger** | 1,200 | 360 | 1,560 |
| 1.7 | **Min Bias Trigger Det** | 136 | 41 | 177 |
| | MIE Totals | 24,547 | 7364 | 31,911 |

# sPHENIX Descope Scenario -2, No IHCal, 85% EMCal

**Baseline Scenario**

**AY k$'s - with Extraordinary Construction Overhead Application**




**Baseline Scenario**

**AY k$'s - with Extraordinary Construction Overhead Application**

| WBS | SYSTEM | FY 2017 | FY 2018 | FY 2019 | FY 2020 | FY 2021 | FY 2022 | Total |
|---|---|---|---|---|---|---|---|---|
| 1.1 | Project Management | 280 | 320 | 320 | 320 | 305 | 305 | 1,850 |
| 1.2 | TPC | 323 | 31 | 1,575 | 675 | 0 | | 2,604 |
| 1.3 | EMCal | 161 | 96 | 4815 | 337 | 323 | | 5,732 |
| 1.4 | HCal | 15 | 129 | 2,752 | 5,427 | 313 | | 8,636 |
| 1.5 | Calorimeter Electronics | 52 | 351 | 3,160 | 598 | 0 | | 4,161 |
| 1.6 | DAQ & Trigger | 19 | 32 | 114 | 1,035 | 0 | | 1,200 |
| 1.7 | Min Bias Trigger Det | 63 | 0 | 19 | 54 | 0 | | 136 |
| | Baseline Total | 913 | 959 | 12,755 | 8,446 | 941 | 305 | 24,319 |
| | MIE Contingency | 274 | 288 | 3,827 | 2,534 | 282 | 92 | 7,296 |
| | MIE Total | 1187 | 1247 | 16582 | 10980 | 1223 | 397 | 31615 |

| WBS | SYSTEM | Baseline | Contingency | Total |
|---|---|---|---|---|
| 1.1 | Project Management | 1,850 | 555 | 2,405 |
| 1.2 | TPC | 2,604 | 781 | 3,385 |
| 1.3 | EMCal | 5,732 | 1720 | 7,451 |
| 1.4 | HCal | 8,636 | 2591 | 11,227 |
| 1.5 | Calorimeter Electronics | 4,161 | 1248 | 5,409 |
| 1.6 | DAQ & Trigger | 1,200 | 360 | 1,560 |
| 1.7 | Min Bias Trigger Det | 136 | 41 | 177 |
| | MIE Totals | 24,319 | 7296 | 31,615 |

# Impacts of the De-scope Options

- Building ½ the EMCal will reduce our acceptance for Upsilons by almost a factor of four. In addition we lose γ+jet statistics, direct γ statistics and our ability to look at jets over a full range of R values due the restrictions on the acceptance. The other physics capabilities of the detector are preserved.

- Building No IHCal will reduce our e/h separation due to leakage out the back of the EMCal which in turn creates a bigger combinatorics background for the upsilon through hadron misidentification as an electron.

- The collaboration has agreed to study the physics impact of these issues in detail and recommend a de-scope option. In the mean time institutions involved with the EMCal (UIUC+UM) and IHCal (ISU&WSU) are investigating the possibility of an NSF MRI proposal or proposals to fund components of these subsystems. Initial talks with Garcia-Solis and Opper of NSF were promising but incipient.

- International funding is also being pursued with IHEP-Protvino as a possible contributor to the IHCal. Other endeavors such as Saclay contributing to the TPC would free up funds that could be directed to restore parts of our de-scoped subsystems. Recent discussions with new potential Chinese collaborators for work on the EMCal also are promising.

# Long Lead-Time Items for Letter or Authorization or CD-3a

**Two options for Long Lead procurements: Letter of Authorization from the Project Management Executive (J. Gillo), or CD-3a authorization.**

| | |
|---|---|
| **SiPMs for EMCal and HCal** | **$1.0M** |
| **Outer HCal Steel** | **$5.3M** |
| **Scintillating Tiles for HCal** | **$1.8M** |
| **Scintillating Fibers for EMCal (1/2 order)** | **$0.7M** |

**Each items has a long production time, long queue time or both. All are for detectors on or near the critical path.**

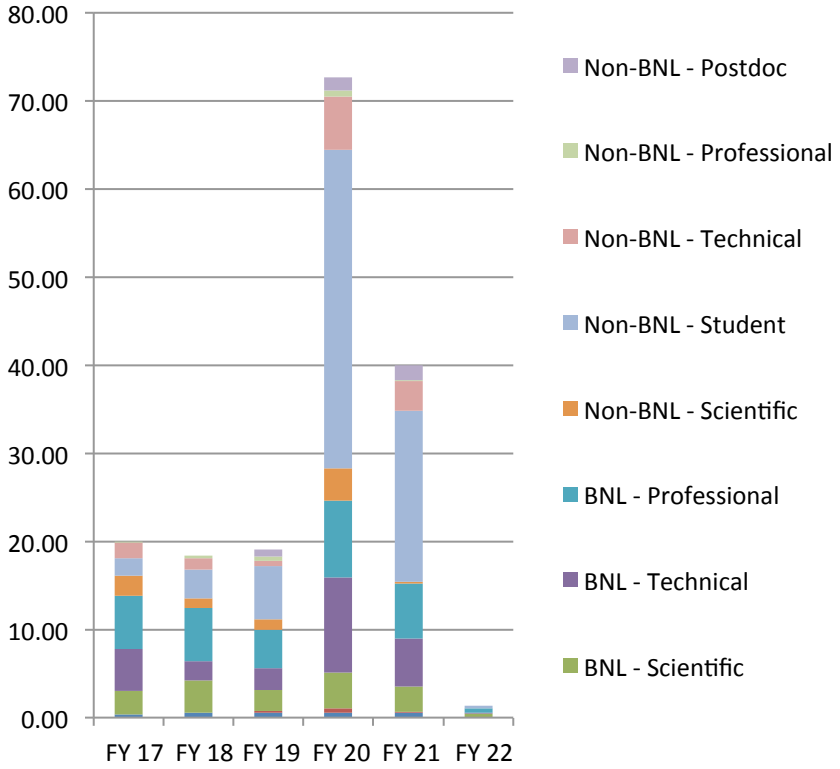
**Procure of those long-lead "items" through authorization from the PME in advance of CD-2 would be carried out via a tailoring strategy (Letter of Authorization)**

**Justification:**

1. Reduce overall project risk
2. Materials will be needed regardless of . . .
3. Contract option already in placed to be executed with excellent price
4. Reduce project schedule
5. Reduce overall cost to project (estimated to be . . . )

# Labor Supporting for sPHENIX MIE

## WBS 1.1 through 1.7




**No FTE contingency shown in plots or spreadsheet**

## FTE Profile

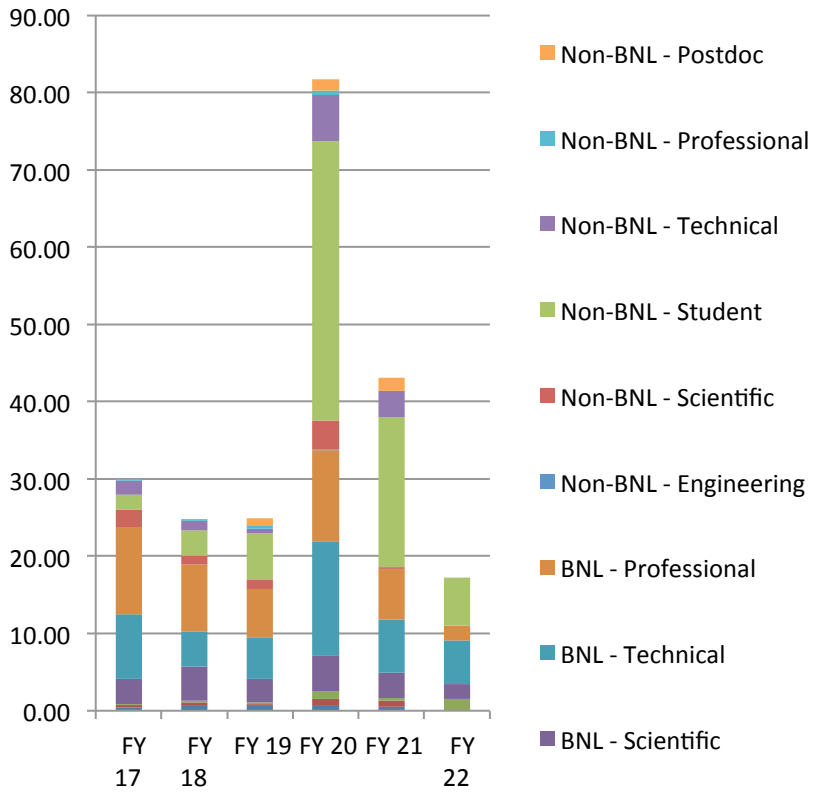
| WBS Level | Group | FY 17 | FY 18 | FY 19 | FY 20 | FY 21 | FY 22 |
|---|---|---|---|---|---|---|---|
| **BNL** | Purchased Services | 0.00 | 0.00 | 0.18 | 0.48 | 0.12 | 0.00 |
| | Scientific | 2.65 | 3.65 | 2.40 | 4.02 | 2.79 | 0.32 |
| | Technical | 4.70 | 2.15 | 2.40 | 10.79 | 5.47 | 0.11 |
| | Professional | 6.10 | 6.03 | 4.38 | 8.73 | 6.23 | 0.55 |
| | Administrative | 0.40 | 0.59 | 0.59 | 0.59 | 0.57 | 0.09 |
| **BNL Sum** | | **13.84** | **12.41** | **9.96** | **24.61** | **15.18** | **1.08** |
| **Non-BNL** | Scientific | 2.24 | 1.12 | 1.21 | 3.68 | 0.20 | 0.00 |
| | Student | 1.96 | 3.29 | 6.05 | 36.16 | 19.43 | 0.27 |
| | Technical | 1.80 | 1.28 | 0.56 | 6.01 | 3.42 | 0.00 |
| | Professional | 0.15 | 0.23 | 0.46 | 0.71 | 0.10 | 0.00 |
| | Postdoc | 0.00 | 0.00 | 0.82 | 1.46 | 1.61 | 0.00 |
| **Non-BNL Sum** | | **6.15** | **5.93** | **9.10** | **48.01** | **24.75** | **0.27** |
| **Grand Total** | | **20.00** | **18.34** | **19.06** | **72.63** | **39.94** | **1.34** |

- The student contribution is commensurate with past student contributions from the same institutions on similar detector projects
- We will secure the non-BNL labor contributions with Memoranda of Agreement between Institutions.

# Labor Supporting MIE+Infra/Facility Upgrade +INTT

## WBS 1.1 – 1.11

### FTE Profile by Category




### FTE Profile by Fiscal Year

| WBS Level | Group | FY 17 | FY 18 | FY 19 | FY 20 | FY 21 | FY 22 |
|---|---|---|---|---|---|---|---|
| **BNL** | Purchased Services | 0.05 | 0.22 | 0.26 | 1.04 | 0.37 | 1.47 |
| | Scientific | 3.29 | 4.39 | 3.03 | 4.64 | 3.21 | 1.94 |
| | Technical | 8.35 | 4.59 | 5.28 | 14.71 | 6.93 | 5.58 |
| | Professional | 11.64 | 9.12 | 6.62 | 12.75 | 7.20 | 1.94 |
| | Administrative | 0.40 | 0.59 | 0.59 | 0.59 | 0.57 | 0.09 |
| **BNL Sum** | | **23.73** | **18.90** | **15.78** | **33.73** | **18.29** | **11.02** |
| **Non-BNL** | Scientific | 2.31 | 1.13 | 1.21 | 3.68 | 0.20 | 0.00 |
| | Student | 1.96 | 3.29 | 6.05 | 36.16 | 19.43 | 6.27 |
| | Technical | 1.80 | 1.28 | 0.56 | 6.01 | 3.42 | 0.00 |
| | Professional | 0.15 | 0.23 | 0.46 | 0.71 | 0.10 | 0.00 |
| | Postdoc | 0.00 | 0.00 | 0.82 | 1.46 | 1.61 | 0.00 |
| **Non-BNL Sum** | | **6.23** | **5.94** | **9.10** | **48.01** | **24.75** | **6.27** |
| **Grand Total** | | **29.95** | **24.84** | **24.88** | **81.75** | **43.04** | **17.29** |

**No FTE contingency shown in plots or spreadsheet**

# Proposed Key Performance Parameters

**Installation is NOT part of the MIE and not a deliverable. Beam collisions are not needed to satisfy the KPP's.**
**Preliminary KPP's listed in the PPEP. They are under Discussion with DOE-ONP**

| System | Demonstration or Measurement | Preliminary KPP's |
|---|---|---|
| Time Projection Chamber | Preinstall Bench Test | $\geq$ 90% live chns based on laser, pulser, cosmics |
| Time Projection Chamber | Preinstall Bench Test | Ion Back Flow $\leq$ 2% per QuadGEM Module |
| Time Projection Chamber | Preinstall Test w/ cosmics | $\geq$ 90% single hit efficiency / mip track |
| Time Projection Chbr FEE | Preinstall Bench Test | Cross talk $\leq$ 2% ea chn |
| EM Calorimeter | Preinstall Bench Test | $\geq$ 90% live channels based on LED, cosmics |
| Hadronic Calorimeter | Preinstall Bench Test | $\geq$ 90% live chns based on LED, cosmics |
| EM Calorimeter | Preinstall Bench Test | Ea sector with an absolute energy pre-calibration to a precision of $\leq$ 35% RMS |
| Hadronic Calorimeter | Preinstall Bench Test | Ea sector with an absolute energy pre-calibration to a precision of $\leq$ 20% RMS |
| Min Bias Trigger Detector | Preinstall Bench Test | $\geq$ 90% live channels based on laser. 120 ps/ch timing resolution w/ Bench Test |
| DAQ/Trigger | Event rate | 10 kHz with random pulser |
| DAQ/Trigger | Data Logging rate | 10 GBit/s with pulser |

# Oversight and Project Meetings

**Oversight**

- Biweekly sPHENIX meeting with DOE BHSO
- Monthly sPHENIX meeting with DOE-ONP
- Monthly PHENIX R&R(decommissioning) meeting with DOE-ONP
- Biweekly meeting with BNL ALD's Project Management Group
- 8 internal BNL reviews of the subsystems
- 2 BNL Director's reviews with external committees.

**Project Meetings**

- Weekly Management meeting
- Weekly simulations meeting
- Biweekly meetings for each MIE subsystems
- Biweekly meetings for SC-magnet
- Biweekly sPHENIX engineering meeting
- Biweekly Tracking meeting
- Biweekly L2 Managers meeting

In addition there is a biweekly General Meeting for the whole collaboration at which the Project reports and a biannual Collaboration meeting.

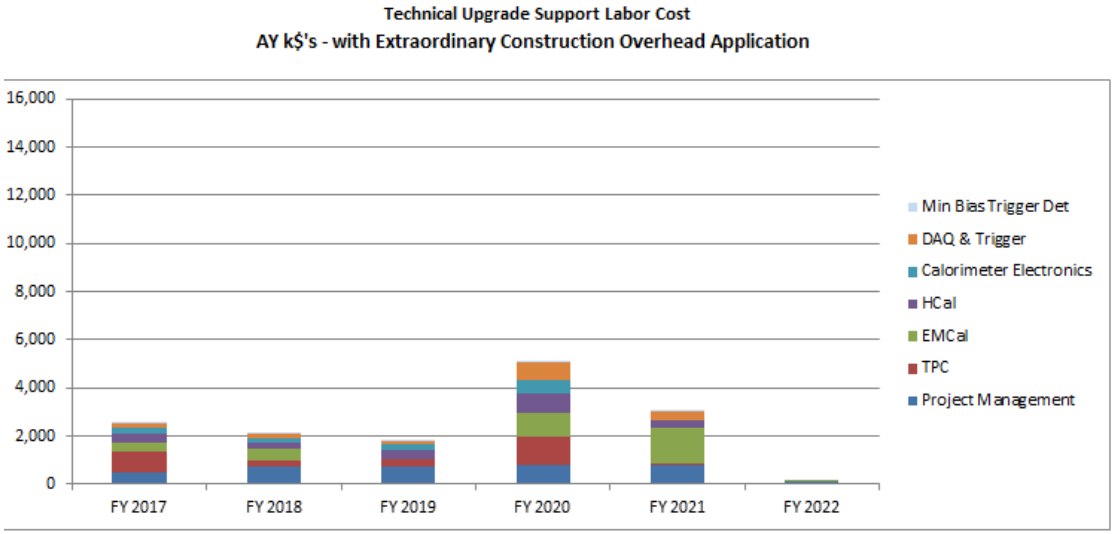
**We've held 900 sPHENIX meetings over the last 3 years. It is a very active collaboration.**

# Summary

- sPHENIX is a major upgrade to the PHENIX experiment that will utilize >$20M in existing equipment. The sPHENIX scientific collaboration is a new organization that was formed 1.5 years ago.
- The sPHENIX Project team is established and has been working together for 3 years.
  - **The Project Organization including L2's and CAMs is established.**
- We have releases or advanced draft of the documents for required for CD-1 including a CDR(300 pages, 200 figures) and a preliminary PEP.
  - **They are available on the review web site.**
- There is a newly revised Resource-loaded schedule with a bottom-up cost and contingency estimate.
  - **We are migrating the RLS schedule in MS-Project to P6. The L2 Managers and CAMs have yet to review the new P6 implementation.**
  - **Bottom-up cost estimate exceeds BNL guidance. We've established two "straw man" technical de-scope scenarios that fit within budget guidance. We are working with the collaboration and BNL to assess the physics impact of those scenarios.**
- Project schedule exists that has the MIE Project complete by Dec 2021. The fully installed and commissioned detector in ready for RHIC collisions Jan 2023 with 8 months float.
  - **The FY18 President's Budget required DOE to delay sPHENIX 1 year**

# Back Up

# sPHENIX Upgrade Support Labor




**Baseline Scenario**

**AY k$'s - with Extraordinary Construction Overhead Application**

| WBS | SYSTEM | FY 2017 | FY 2018 | FY 2019 | FY 2020 | FY 2021 | FY 2022 | Total |
|---|---|---|---|---|---|---|---|---|
| 1.1 | **Project Management** | 481 | 716 | 761 | 802 | 820 | 139 | 3,719 |
| 1.2 | **TPC** | 894 | 252 | 287 | 1,162 | 29 | | 2,624 |
| 1.3 | **EMCal** | 375 | 505 | 7 | 985 | 1489 | 46 | 3,407 |
| 1.4 | **HCal** | 367 | 259 | 392 | 813 | 316 | | 2,147 |
| 1.5 | **Calorimeter Electronics** | 235 | 152 | 217 | 576 | 32 | | 1,212 |
| 1.6 | **DAQ & Trigger** | 170 | 231 | 123 | 704 | 351 | | 1,579 |
| 1.7 | **Min Bias Trigger Det** | 58 | 25 | 3 | 38 | 5 | | 129 |
| | Baseline Total | 2,580 | 2,140 | 1,790 | 5,080 | 3,042 | 185 | 14,817 |
| | MIE Contingency | 774 | 642 | 537 | 1,524 | 913 | 56 | 4,445 |
| | MIE Total | 3354 | 2782 | 2327 | 6604 | 3955 | 241 | 19262 |

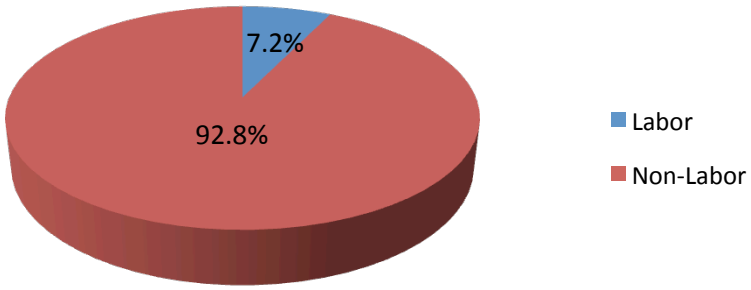
| WBS | SYSTEM | Baseline | Contingency | Total |
|---|---|---|---|---|
| 1.1 | **Project Management** | 3,719 | 1116 | 4,835 |
| 1.2 | **TPC** | 2,624 | 787 | 3,411 |
| 1.3 | **EMCal** | 3,407 | 1022 | 4,429 |
| 1.4 | **HCal** | 2,147 | 644 | 2,791 |
| 1.5 | **Calorimeter Electronics** | 1,212 | 364 | 1,576 |
| 1.6 | **DAQ & Trigger** | 1,579 | 474 | 2,053 |
| 1.7 | **Min Bias Trigger Det** | 129 | 39 | 168 |
| | MIE Totals | 14,817 | 4445 | 19,262 |

**30% Labor contingency included In budget**

# Funding Split M&S and Labor

## Capital Project Scope

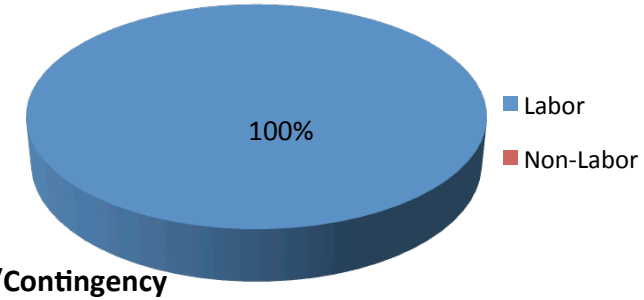
### sPHENIX - Major Item of Equipment (MIE)




**38.6 AY K$ w/Contingency**
**32 AY K$ w/ Contingency after descope**

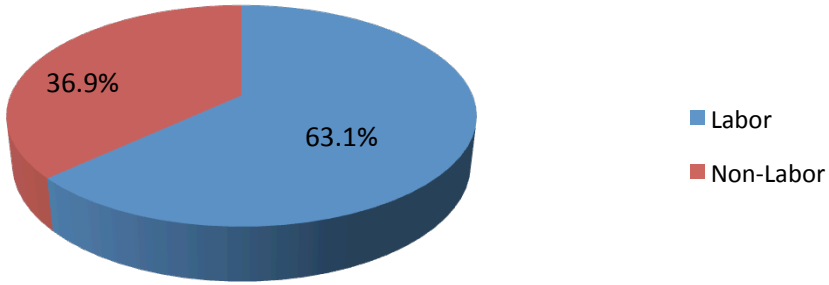
## RHIC Operations Scope

### Upgrade Support




**19.2 AY K$ w/Contingency**

### Infrastructure & Facility Upgrade




**18.3 AY k$ w/Contingency**

# Risk Matrix

Uniformly Applied Graded Approach to Risk Across All Subsystems

**Table 3: Impact Assessment Matrix for Project-Level Global Risks**

| Impact<br>Risk Area | Low | Moderate | High |
|---|---|---|---|
| Cost: | ≤ $250K | ≤$500K | >$500K |
| Schedule: | Delays Level 2 milestone or Project critical path by ≤3 month | Delays Level 2 milestone or Project critical path by ≤6 months | Delays Level 2 milestone or Project critical path by >6 months |
| Scope/Technical: | Negligible, if any, degradation. | Significant technical/scope degradation. | Baseline scope or performance requirements will not be achieved. |

**Table 6: Risk Classification Matrix**

| | Impact | | |
|---|---|---|---|
| **Probability** | **Low** | **Moderate** | **High** |
| **High (probability > 75%)** | Moderate | High | High |
| **Moderate (25% < probability < 75%)** | Low | Moderate | High |
| **Low (probability < 25%)** | Low | Low | Moderate |

# sPHENIX BOE Contingency Guidelines

Labor Bottom-Up Contingency - Uniformly Graded Approach to Risk Across All Subsystems

| | Type of Estimate | Contingency % | Description |
|---|---|---|---|
| L1 | Actual | 0% | Actual costs incurred on activities completed to date. |
| L2 | Level of Effort Tasks | 0%–20% | Support type activities that must be done to support other work activities or the entire project effort, where estimated effort is based on the duration of the activities it is supporting. |
| L3 | Advanced | 10%–25% | Based on experience with documented identical or nearly identical work. Development of activities, resource requirements, and schedule constraints are highly mature. Technical requirements are very straightforward to achieve. |
| L4 | Preliminary | 25%–40% | Based on direct experience with similar work. Development of activities, resource requirements, and schedule constraints are defined as preliminary (beyond conceptual) design level. Technical requirements are achievable and with some precedent. |
| L5 | Conceptual | 40%–60% | Based on expert judgment using some experience as a reference. Development of activities, resource requirements, and schedule constraints are defined at a conceptual level. Technical requirements are moderately challenging. |
| L6 | Pre-conceptual | 60%–80% | Based on expert judgment without similar experience. Development of activities, resource requirements, and schedule constraints are defined at a pre-conceptual level. Technical requirements are moderately challenging. |
| L7 | Rough Estimate | 80%–100% | Based on expert judgment without similar experience. Development of activities, resource requirements, and schedule constraints is largely incomplete. Technical requirements are challenging. |
| L8 | Beyond state of the art | > 100% | No experience available for reference. Activities, resource requirements, and schedule constraints are completely undeveloped. Technical requirements are beyond state of the art. |

# Technical Status

**1.2 TPC:** Mechanical design is advanced. In 1st round of prototyping but we're building on ALICE, STAR and EIC R&D work. Full scale prototype with limited readout, ready fall 2017.

Two electronics boards needed FEE and DAM. Both based on existing boards.

1st prototype FEE produced & being tested in BNL Instrumentation. Similar to both ALICE & STAR boards.

DAM will be ATLAS FELIX board w/ new firmware. Testing in BNL Instrumentation has started with FELIX 1.5

**1.3 EMCal:** 2nd round of prototyping complete. Test beam analysis ongoing but initial results show that we are going to meet performance spec. Needs 1 more round of small prototype plus preproduction.

**1.4 HCal:** Advanced. 2ND round of prototyping complete. Meets performance specs. Detector design complete. Full size mech prototype for IHCal exists. Full size prototype for OHCal complete at vendor in 2 weeks. Working on installation plans.

**1.5 Calorimeter Electronics:** Advanced. Hamamatsu SiPM chosen. Preamp design done except for optimization of form factor(board size and shape). Digitizer board done. Working on back plane and crate controller. Nine months from ready to start production.

**1.6 DAQ/Trigger:** Costed upgrade commercial equipment for existing DAQ. Trigger simulations to identify rejection requirements.

**1.7 Min Bias Detector:** Reuse of existing PHENIX Detector.

**1.8 Magnet:** Exists. Former BaBar magnet passed cold low-field test. Full-field test Sept 2017. Conceptual design exists for cryo, PS, controls.

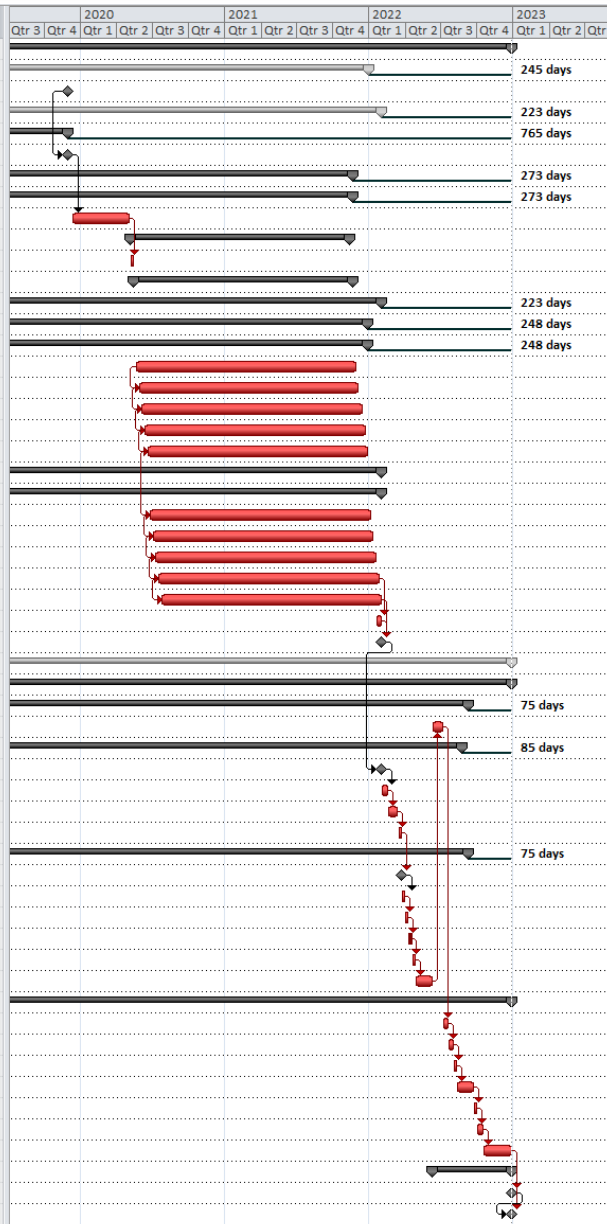
**1.9 Infrastructure:** Early planning stages.

**1.10 Integration & Installation:** Conceptual design exists for outer detector. Engineering work started for for inner detectors: TPC, INTT, MVTX, Min Bias Det.

**1.11 Intermediate Tracker:** First round of prototyping with Si strip ladder produced and being tested at BNL.

# sPHENIX Critical Path EMCal through Installation

| WBS | Name | Duration | Start | Finish |
|---|---|---|---|---|
| **1** | **sPHENIX_Project** | **1409 days** | **2/1/17** | **9/26/22** |
| **1.1** | **sPHENIX_Project_Management** | **1164 days** | **2/1/17** | **9/30/21** |
| 1.1.8 | Receive CD2/CD3 Authorization | 0 days | 8/30/19 | 8/30/19 |
| **1.3** | **sPHENIX_EMCal** | **1186 days** | **2/1/17** | **11/1/21** |
| **1.3.1** | **EMCAL Management** | **644 days** | **2/1/17** | **8/30/19** |
| 1.3.1.5 | CD-2b/CD-3b Authorization | 0 days | 8/30/19 | 8/30/19 |
| **1.3.2** | **EMCAL Block Production** | **1095 days** | **3/31/17** | **8/20/21** |
| **1.3.2.3** | **EMCAL Final Block Production** | **1056 days** | **5/25/17** | **8/20/21** |
| 1.3.2.3.10 | Set up factory for final blocks | 98 days | 9/9/19 | 1/31/20 |
| **1.3.2.3.13** | **Fabricate final blocks** | **384 days** | **2/3/20** | **8/13/21** |
| 1.3.2.3.13.1 | Fabricate final blocks sector 1 | 6 days | 2/3/20 | 2/10/20 |
| **1.3.2.3.14** | **Pack and ship final blocks to BNL** | **383 days** | **2/11/20** | **8/20/21** |
| **1.3.3** | **EMCAL Module Production and Sector Assembly** | **1167 days** | **3/1/17** | **11/1/21** |
| **1.3.3.2** | **EMCAL Module Production** | **1142 days** | **3/1/17** | **9/27/21** |
| **1.3.3.2.3** | **EMCAL Final Module Production** | **831 days** | **5/29/18** | **9/27/21** |
| 1.3.3.2.3.6 | Receive, unpack, log & inspect final blocks | 384 days | 2/18/20 | 8/27/21 |
| 1.3.3.2.3.7 | Install light guides on final blocks | 384 days | 2/25/20 | 9/3/21 |
| 1.3.3.2.3.8 | Install reflectors and mounting supports on final blocks | 384 days | 3/3/20 | 9/13/21 |
| 1.3.3.2.3.9 | Install SiPMs & daughterboards on final blocks | 384 days | 3/10/20 | 9/20/21 |
| 1.3.3.2.3.10 | Glue final blocks together into modules | 384 days | 3/17/20 | 9/27/21 |
| **1.3.3.3** | **EMCAL Sector Assembly** | **1144 days** | **4/3/17** | **11/1/21** |
| **1.3.3.3.3** | **EMCAL Final Sector Assembly** | **1144 days** | **4/3/17** | **11/1/21** |
| 1.3.3.3.3.11 | Install modules in final sectors | 384 days | 3/24/20 | 10/4/21 |
| 1.3.3.3.3.12 | Install readout electronics on final sectors | 384 days | 3/31/20 | 10/11/21 |
| 1.3.3.3.3.13 | Install cables & cooling system on final sectors | 384 days | 4/7/20 | 10/18/21 |
| 1.3.3.3.3.14 | Test final sectors with LEDs & cosmic rays | 384 days | 4/14/20 | 10/25/21 |
| 1.3.3.3.3.15 | Repair or rework any sectors as required | 384 days | 4/21/20 | 11/1/21 |
| 1.3.3.3.3.16 | Installation Readiness Review | 10 days | 10/19/21 | 11/1/21 |
| 1.3.4 | Install sectors into sPHENIX | 0 days | 11/1/21 | 11/1/21 |
| **1.10** | **sPHENIX_Integration_and_Installation** | **1409 days** | **2/1/17** | **9/26/22** |
| **1.10.2** | **Integration Management and Technical Coordination, Installation Tooling and Fixt** | **1409 days** | **2/1/17** | **9/26/22** |
| **1.10.2.2** | **Infrastructure Installation** | **1124 days** | **12/4/17** | **6/8/22** |
| 1.10.2.2.3 | Install Beampipe/Vacuum/Bakeout | 20 days | 3/9/22 | 4/5/22 |
| **1.10.2.7** | **EMCal Installation** | **1324 days** | **2/1/17** | **5/24/22** |
| 1.10.2.7.7 | EMCal Sectors Ready for Installation | 0 days | 11/1/21 | 11/1/21 |
| 1.10.2.7.8 | Transport Assembled EMCal Sectors to AH | 10 days | 11/2/21 | 11/16/21 |
| 1.10.2.7.9 | Install EMCal Sectors | 16 days | 11/17/21 | 12/10/21 |
| 1.10.2.7.10 | Align/Survey EMCal to SC Magnet Centerline | 7 days | 12/13/21 | 12/21/21 |
| **1.10.2.8** | **TPC Installation** | **1334 days** | **2/1/17** | **6/8/22** |
| 1.10.2.8.7 | TPC Ready for Installation | 0 days | 12/21/21 | 12/21/21 |
| 1.10.2.8.8 | Transport Assembled TPC Sections to AH | 5 days | 12/22/21 | 12/30/21 |
| 1.10.2.8.9 | Install TPC Support | 5 days | 12/31/21 | 1/7/22 |
| 1.10.2.8.10 | Install TPC (Mechanical) | 5 days | 1/10/22 | 1/14/22 |
| 1.10.2.8.11 | Align/Survey TPC to SC Magnet Centerline | 5 days | 1/18/22 | 1/24/22 |
| 1.10.2.8.12 | Install TPC Cables and Services | 30 days | 1/25/22 | 3/8/22 |
| **1.10.2.11** | **Min Bias Installation** | **1409 days** | **2/1/17** | **9/26/22** |
| 1.10.2.11.9 | Install Min Bias Support | 10 days | 4/6/22 | 4/19/22 |
| 1.10.2.11.10 | Install Min Bias (mechanical) | 10 days | 4/20/22 | 5/3/22 |
| 1.10.2.11.11 | Align/Survey Min Bias to SC Magnet Centerline | 5 days | 5/4/22 | 5/10/22 |
| 1.10.2.11.12 | Install Min Bias Cables and Services | 30 days | 5/11/22 | 6/22/22 |
| 1.10.2.11.13 | Review Min Bias for Operational Readiness (ORR) | 5 days | 6/23/22 | 6/29/22 |
| 1.10.2.11.14 | Address Action Items from Min Bias ORR | 10 days | 6/30/22 | 7/15/22 |
| 1.10.2.11.15 | Commission Min Bias | 50 days | 7/18/22 | 9/26/22 |
| **1.10.2.12** | **sPHENIX Full Detector Installation** | **140 days** | **3/9/22** | **9/26/22** |
| 1.10.2.12.9 | All Design/Safety/Readiness Reviews Complete, sPHENIX Ready for Operatic | 0 days | 9/26/22 | 9/26/22 |
| 1.10.9 | sPHENIX Ready for Run 1 | 0 days | 9/26/22 | 9/26/22 |



# sPHENIX Extraordinary Project Rates

**sPHENIX Upgrade and Support Projects**
**Composite Rates - Assumes Cost Accounts are under "DB" - NPP Directorate**

| Row Labels | Category | Description | EPR Rate TMC FY 17 - FY18 | EPR Rate VAB FY 19 - on |
|---|---|---|---|---|
| Low value material | 300 | PO Purchases | 0.28 | 0.12 |
| Travel | 280 | Foreign Travel | 0.28 | 0.33 |
| | | | | |
| | | | | |
| Capital Equipment | 425 | HI Value - Laboratory | 0.11 | 0.12 |
| High Value > 25k | 216 | R&D Sub-Contract | 0.17 | 0.12 |
| | | | | |
| | 190 | Contract Labor | 0.19 | 0.23 |
| Salary | 50 | Labor | 0.22 | 0.25 |
| | | | | |

EPR - Extraordinary Project Rate
TMC- Total Modified Cost
VAB – Value Added Base