Core Facility Revitalization (CFR)

Critical Decision 1 (CD-1) Independent Project Review

Campus Strategy

Marty Fallier,

Site Planning &

Infrastructure Management

Facilities and Operations

August 23rd, 2016

BROOKHAVEN NATIONAL LABORATORY

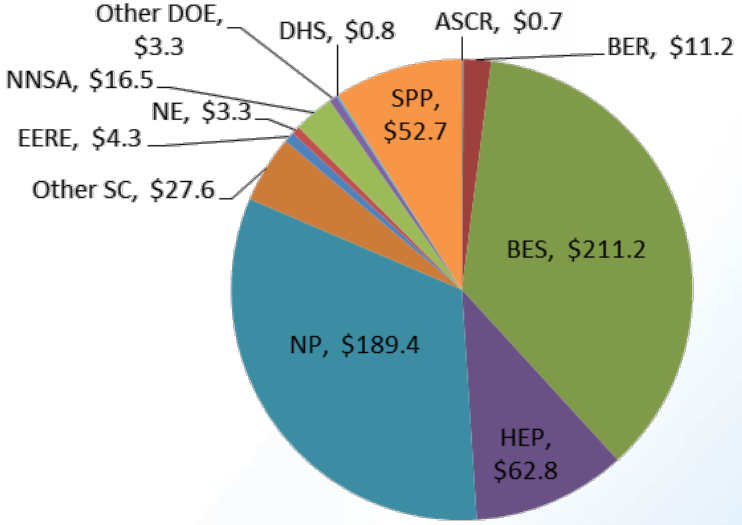
a passion for discovery

U.S. DEPARTMENT OF ENERGY | Office of Science

Brookhaven National Laboratory at a Glance: FY 2015

- Physical Assets
  - 5322 acres
  - 312 buildings (4.8MSF)
- Human Capital
  - 2671 FTEs (2807 heads)
  - Direct/indirect: 0.59/0.41
  - 133 postdoctoral researchers

FY 2015 Funding by Source ($M)



FY 2015 Total Lab Operating Costs (excluding Recovery Act): $584M
FY 2015 Total DOE/NNSA Costs: $16.5M
FY 2015 SPP (Non-DOE/Non-DHS) Costs: $53M
FY 2015 SPP as % Total Lab Operating Costs: 9.0 %
FY 2015 DHS Costs: $0.8M

The BNL campus vision

Providing a revitalized physical plant to enable our science, attract and retain the scientific work force, support the needs of users, and assure the reliable functioning of BNL's scientific facilities

Critical Outcomes

- Understanding the origins of matter and mass
- Transformational discovery through synchrotron science
- *In operando* and *in situ* energy science leadership
- Leadership in data-driven discovery
- Renewed research campus that enables BNL's research mission
- Safe, efficient operations that ensure delivery of BNL's research mission

Ten-year campus strategy

BSA's plan to deliver the next decade of science while transforming the Laboratory Campus

I. Improve capability of critical core buildings to enable the scientific agenda

II. Enhance safety and cost effectiveness by optimizing the campus footprint and demolishing old buildings

III. Ensure scientific facility reliability through targeted utility and infrastructure investments

IV. Renew infrastructure and support the growing population of scientific users through an innovative public-private concept of *Discovery Park*

DOE investments are having an impact

Moving toward safe, mission-ready science facilities and infrastructure

Recent DOE investments have had a substantial impact on BNL's landscape

- Built ~870K sq. ft. of new research and support facilities
  - Increased science capability & increased demand for computational capability
- Reduced average age of facilities by a net reduction of 8 years
- Renovated ~124K sq. ft. of core science buildings
  - Experience in successfully renovating major facilities
- Revitalized facilities have driven a positive change in spirit and culture

Science Core Investment Projects

SLI Line Items critical to revitalizing infrastructure to meet mission needs

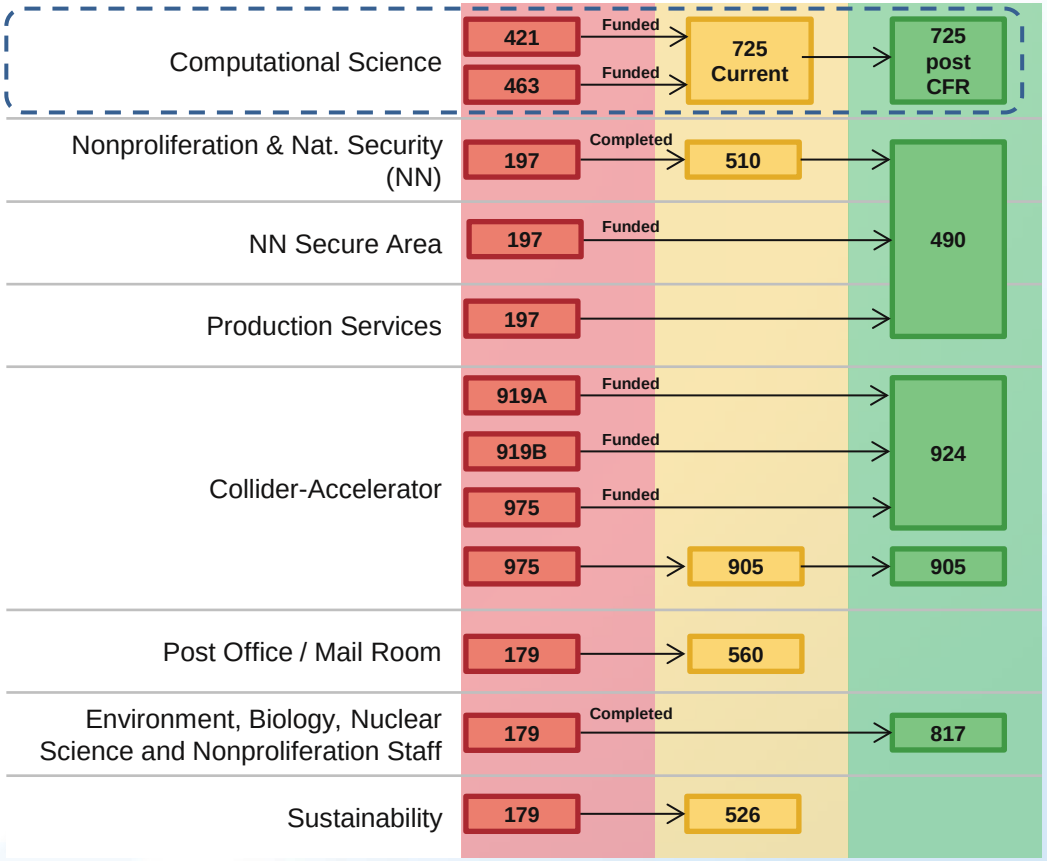
- Core Facility Revitalization (CFR) - *SLI Proposed FY17 start*
  - Addresses key mission gaps for reliability and growth and capable computing facilities for NP and HEP RHIC/Atlas computing
- Science and User Support Center (SUSC) - *SLI Proposed FY18 start*
  - Driven by Alternatives Analysis for Discovery Park
  - Addresses key gaps in support facilities for large visiting science User community and infrastructure renewal for dispersed support organizations
- Building 911 Revitalization -*SLI Proposed FY21 start*
  - Revitalizes 1950's and 1960's vintage collider and accelerator engineering and operations facility
  - Addresses key gaps in providing up to date, fully functional and sustainable facilities to serve the NP and HEP missions

Space Reduction Plan

BNL has an ongoing multi-year plan to move out of (and demolish) old, inadequate buildings

- Plan Elements:
  - Migrate from deteriorated small, WW-II era buildings and plan for excess & demolition
  - Consolidate into better quality space meeting mission needs
  - Renovate larger more efficient buildings to achieve sustainable footprint
- Bldg 725 CFR Alternative are important components of the Space Reduction Plan
- The Plan will ultimately enable demolition of ~470,000 SF of non-sustainable space

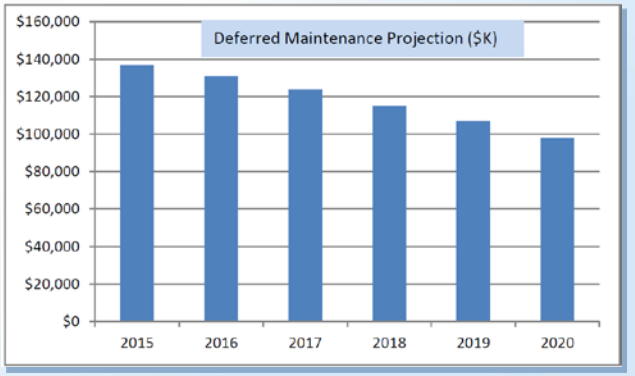
Sample of planned BNL building moves & consolidation



Includes move out, excess and demolition of over 30 additional buildings

BNL Campus Strategy

- Our goal is to accelerate the visible transformation that is already underway
- The infrastructure plan, as indicated in the BNL ALP, leverages a diversity of funding sources to achieve the scientific agenda for the next decade
- The CFR Project is a key element of that plan
- Infrastructure and science strategies are aligned to achieve BNL's ten-year vision
  - Invest in existing science core buildings
  - Cost saving through downsizing the footprint
  - Targeted investments in utility infrastructure
  - Explore innovative options for enhanced user support & infrastructure renewal through Discovery Park
- Execution of our strategy will enhance mission readiness and enable a sustainable future



Core Facility Revitalization (CFR)

Critical Decision -1 (CD-1) Independent Project Review

BNL - Computational Science Initiative (CSI)

Kerstin Kleese van Dam

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Brookhaven National Laboratory

- Utilizes its world-class facilities and expertise to:
  - Advance energy and environment-related basic research
  - Advance fundamental research in nuclear and particle physics
- In this the ability to make sense of data is foundational to all discoveries, innovation and decision making.
- Science and National Security Missions are driven by the need to assimilate and interpret ever-increasing volumes and rates of data, to accelerate scientific discovery and make critical decisions.
- **Underpinning State of the Art Data, Computing and Networking Infrastructure is essential to fulfill BNL's Mission.**

RHIC

NSLS II

CFN

LISF

SDCC

Computational Science Initiative (CSI)

- Established December 2015
- Provides the umbrella for Computer Science, Applied Mathematics and Computational Science Research and Services at BNL
- **Vision - Translating Leading Computer Science and Applied Mathematics Research into Measurably Improved Scientific Discovery Processes**
- **Focus - Data Analysis, Numerical Modeling Support for Experiments, Reusable Knowledge Repositories**
- At present 70 staff and Students
- Startup $15M in NY State Funding over 5 Years and matching BNL investment, funding from ASCR, BES, BER, HEP, NP, ARPA-E

CSI Structure

- CSI Director - Kerstin Kleese van Dam
- Chief Scientist - Robert Harrison

- 4 Divisions:
- **Computer Science and Mathematics** - leading edge research in data intensive computing from architectures to applications - Director: Barbara Chapman
- **Computational Science Laboratory** - Collaborative Center for Advanced Algorithm Development and Optimization - bringing together HPC, Math and Domain Science Expertise - Director: Nick D'Imperio
- **Center for Data Driven Discovery** - Multidisciplinary Center for the Development, Deployment and Operation of Data Driven Discovery Services - Interim Director: Kerstin Kleese van Dam

- **BNL Scientific Data and Computing Center - providing state of the art data, computing and networking infrastructure, incl. RACF - Director: Eric Lancon**

Computer Science and Mathematics

- **Research Focus - Integrated Approach to Data Science at Scale:**

- **Development of Novel Computational Devices** - QCDOC, IBM Blue Gene Series, Intel KNL Series
- **Leading Programming Model and Compiler Development** - Focus on high performance and performance portability
- **Fast IO** - Fast data I/O and transfer
- **PanDa -** Global Data and Compute Resource Scheduler
- **Machine Learning** - Streaming, Deep, On the Wire
- **Numerical Libraries** -Particle Methods
- **Visual Analytics** - Combining machine learning and visualization to support decision making
- **Provenance** - For Result Explanation, Reproducibility and Performance

- **Leading edge research to develop the next generation of experimental planning and analysis tools.**

Barbara Chapman

Computational Science Laboratory

Nick D'Imperio

- **Collaborative Center - Supporting better exploitation of new computer architectures to enable scientific discoveries**
- Team of Computational Scientists from Different Disciplines. Specifically: QCD, Materials and Chemistry, growing: Biology and Climate
- Regular Training provided: MPI, OpenMP, OpenACC etc.
- Community centric User Support e.g. QCD - RIKEN, USQCD
- **Enabling the development of advanced modeling capabilities at BNL in support of experiments e.g. QCD for RHIC**

Center for Data Driven Discovery

- **Collaborative Center - Translating Research Results into Improved Data-Driven Discovery**
- Team of Computer Scientists, Mathematicians and Domain Scientists.
- Development of new data analysis solutions and their operation.
  - **Complex Modeling** - Integration of data analysis and numerical modeling
  - **BER Kbase Partner** - Advanced analytical algorithms for Systems Biology Research
  - **Near real time data analysis for experiments** - NSLS II and CFN solutions leveraging machine learning and visual analysis
- **Creating the next generation of data management and analysis methods, tools and services.**

Scientific Data and Computing Center

Eric Lancon

- **To facilitate CSI's data analysis research and its translation into tools and services that truly accelerate scientific discovery requires a state of the art data, computing and network infrastructure.**

- SDCC is housing and operating all of CSI's computational infrastructure incl. RACF. Next to High Throughput Computing (RACF) it also provides:

- High Performance Computing:
  - 2007 IBM BlueGene/L - No. 5 Top 500, 2009 IBM BlueGene/P - No. 250 Top 500, 2011 IBM BlueGene/Q - No. 6 Graph Top 500
  - **2016 Institutional Cluster**: 108 (upgrade to 200 in FY17) compute nodes of 36 Broadwell CPU's, 2 Nvidia K80 GPUs, 1 PB disk
- **2016 Novel Data-Intensive Architecture Testbed Facility:**
  - Initial system: 144 Nodes with 64 Intel Xeon Phi Processors 7230 (Knights Landing)

Scientific Data and Computing Center

- **In 2016 alone CSI took on 4 new services (HEP, NP, BES, BNL) growing from 3% to 22% of overall Computing in SDCC.**
- To accommodate this growth ~$300,000 were invested in upgrades to the electrical and cooling infrastructure in Bldg. 515.
- Further $50,000 were invested in studies to determine further work required to enable further growth. **Conclusion:** Current space insufficient to support immediate requirements, need to continue use of Bldg. 459 and early retirement of existing equipment needed.

- **New Data Center is critical for BNL to meet DOE's Mission**

Core Facility Revitalization (CFR)

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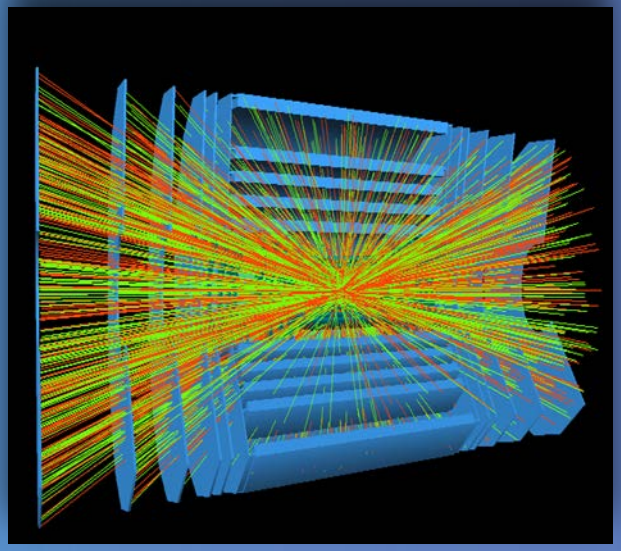

The RHIC and ATLAS Computing Facility

Eric Lançon

Physics Department

August 23rd – 25th, 2016

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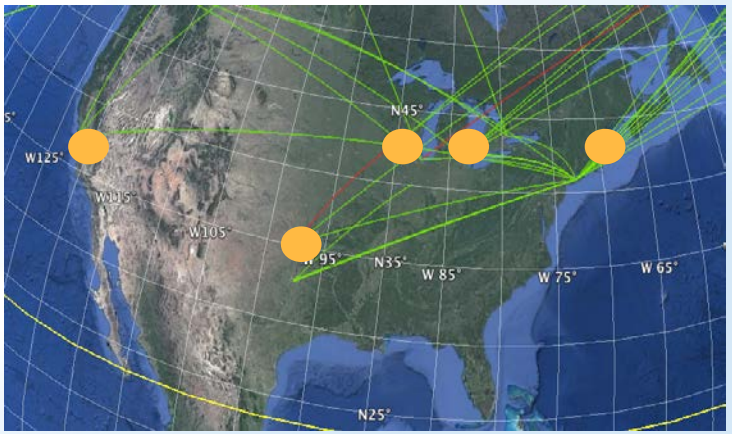
RACF : The RHIC and ATLAS Computing Facility

- A world class HEP and NP facility
  - Grew organically to support computational needs of NP, QCD, RHIC and US-ATLAS communities at large
  - Expertise and infrastructure necessary for leadership & innovation in data-driven discovery
- The RHIC Tier 0
- The US ATLAS Tier 1
- The computing center of CSI, BNL's Computational Science Initiative, **SDCC** (Scientific Data and Computing Center) is housed in RACF and operated by RACF staff

RACF : The RHIC and ATLAS Computing Facility

- **The RHIC Tier 0**
  - Store and process data from RHIC experiments
  - Provide analysis means for thousands of users

- **The US ATLAS Tier 1**
  - **99%** service availability requirement (MoU)
  - ~25% of ATLAS Tier 1 computing capacity worldwide
  - Store RAW data from LHC and from simulation
  - Distribute data to the 5 US Tier 2 sites
  - Analysis center for US physicists

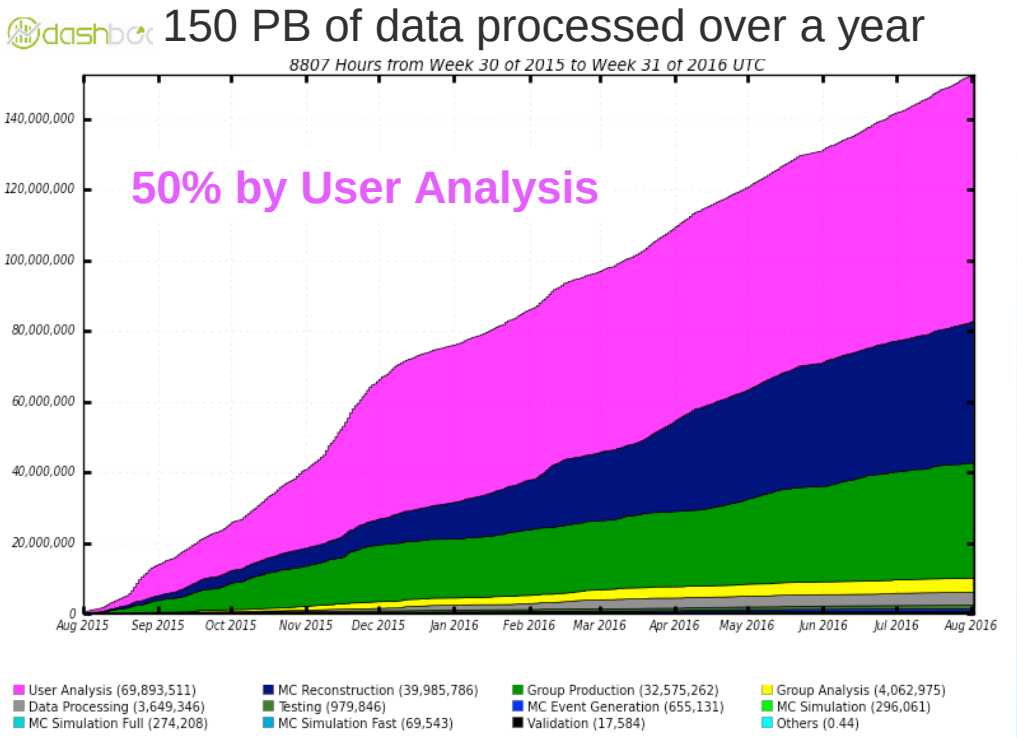


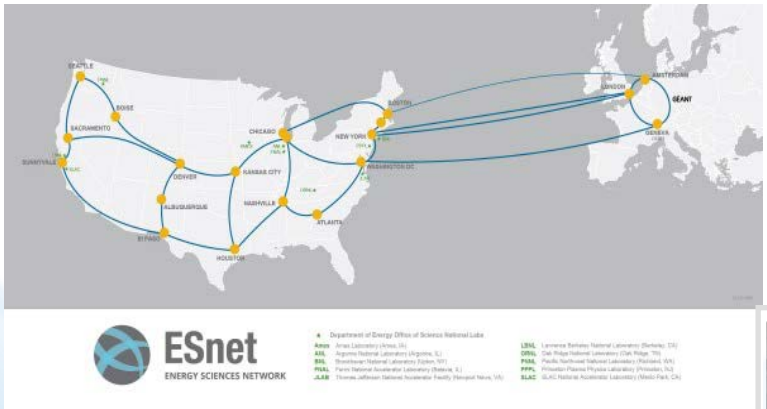
Expertise

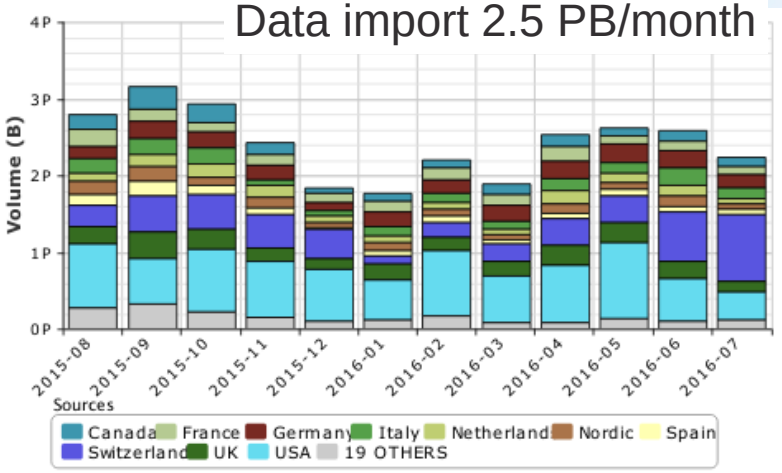
- **HTC** : High Throughput Computing
  - Leadership in data driven computing
  - Supporting 1000s of users
- **Data storage and archiving**
  - Disk storage
  - Tape archive
- **Networking**
  - WAN : High performance Wide Area Network transfers (in collaboration with ESnet)
  - LAN : Local Area Network with Terabit scale capability

RACF: Big Data Science

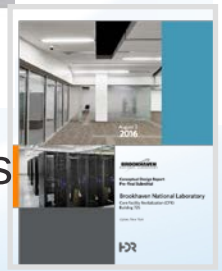
- Expertise in storing, processing, distributing and providing resources for analysis of big data samples
- Over a year
  - Data import : 30 PB
  - Data export : 32 PB
  - 150 PB processed





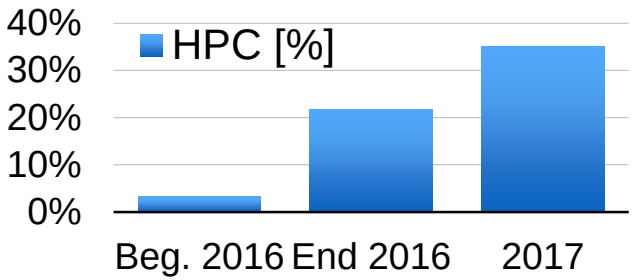


1 PB = 25M CFR documents



RACF in Numbers

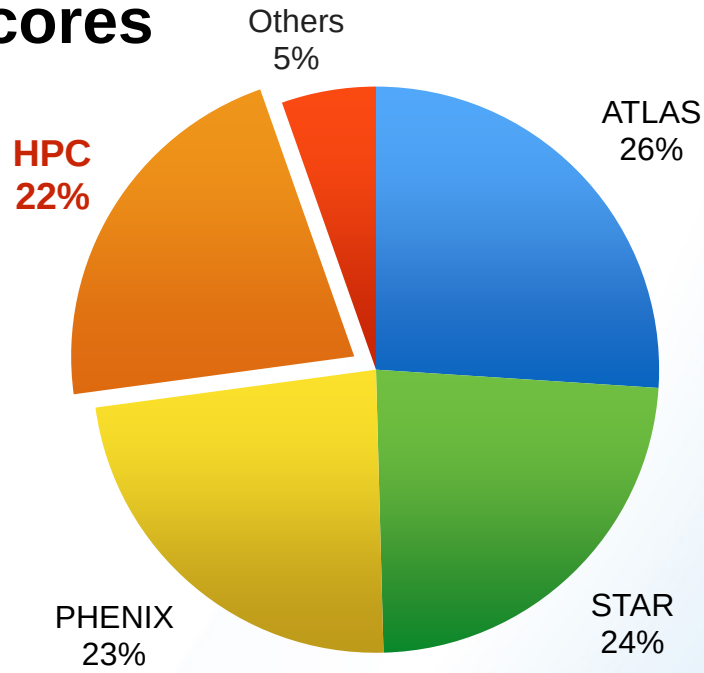
- **70k CPU cores (~100k in 2017)**
  - HPC 22% of capacity



- **~50 PB of disk storage**
  - of various technologies

- **~80 PB of tape storage**
  - 4th HPSS (High Performance Storage System) site worldwide
  - first within the US(1)

70k cores



HPSS sites

Site
(ECMWF) European Centre for Medium-Range Weather Forecasts
(NOAA-RD) National Oceanic and Atmospheric Administration Research & Development
(UKMO) United Kingdom Met Office
(BNL) Brookhaven National Laboratory
(LBNL-User) Lawrence Berkley National Laboratory - User
(LANL-Secure) Los Alamos National Laboratory - Secure
(ORNL) Oak Ridge National Laboratory
(NCAR) National Center for Atmospheric Research

(1) http://www.hpss-collaboration.org/learn_who_petabyte_data.shtml

RACF and RHIC - the next 5 years

- Resources for PHENIX & STAR experiments data reconstruction and analysis
  - Analysis continues more than 5 years after data taking
  - 1000s of users
- Simulation needs for
  - sPHENIX : detector optimisation and data taking
  - eRHIC optimisation

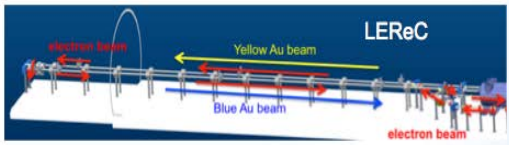
The Ongoing Science Mission

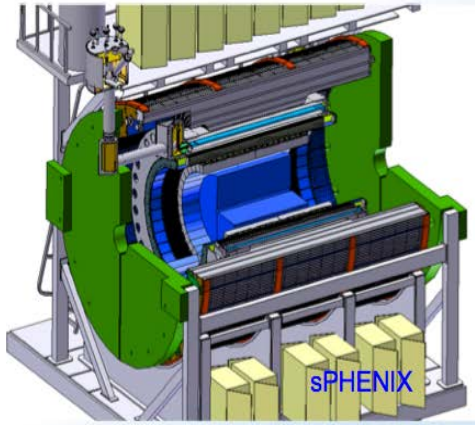
Status: RHIC-II configuration is complete

- Vertex detectors in STAR (HFT) and PHENIX
- Luminosity reaches 25x design luminosity

Plan: Complete RHIC mission in 3 campaigns:

- **2014–18: Heavy flavor probes of the QGP**
  Transverse spin physics
  Isobar system test of QCD anomalies
- *2018: Install low energy e-cooling*
- **2019/20: High precision scan of the QCD phase diagram & search for critical point**
- *2021: Install sPHENIX*
- **2022-??: Probe perfect liquid QGP with precision measurements of jet quenching and Upsilon suppression**
- *Transition to eRHIC?*





RHIC remains a unique discovery facility

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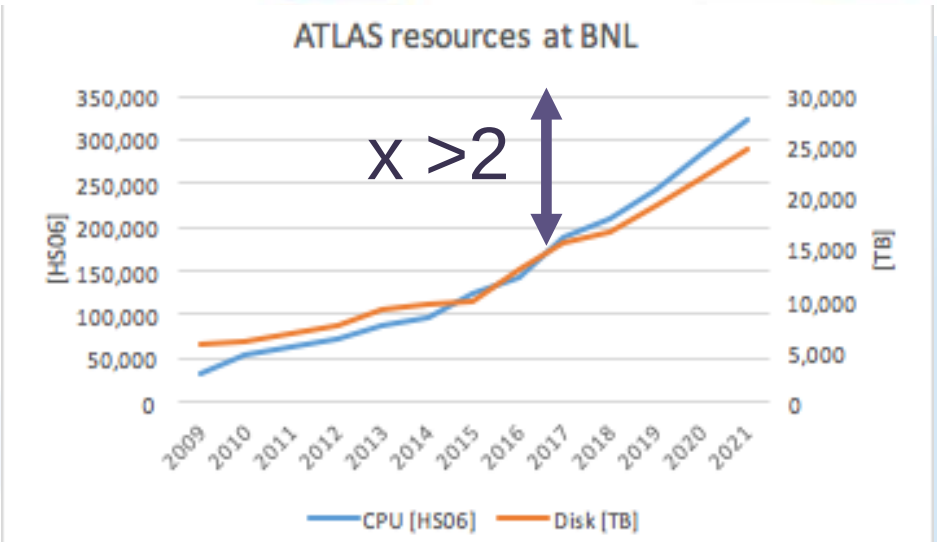
Moderate growth of computing needs (5-10%/year)

ATLAS and the LHC Program

- Growth of resources ~25%/y until Run 3
- LHC data deluge will continue
- New hardware requirements (HPC type) from ATLAS software migration to multi-threading (Run 3)



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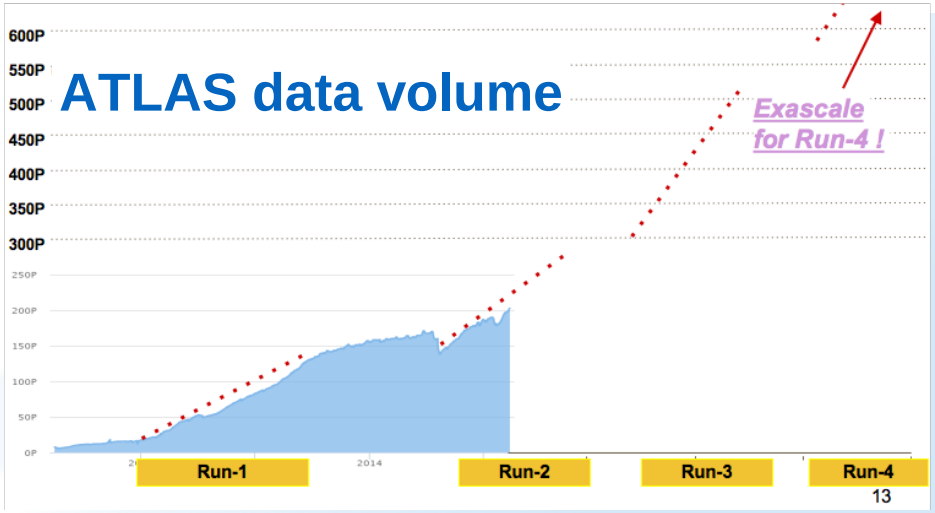
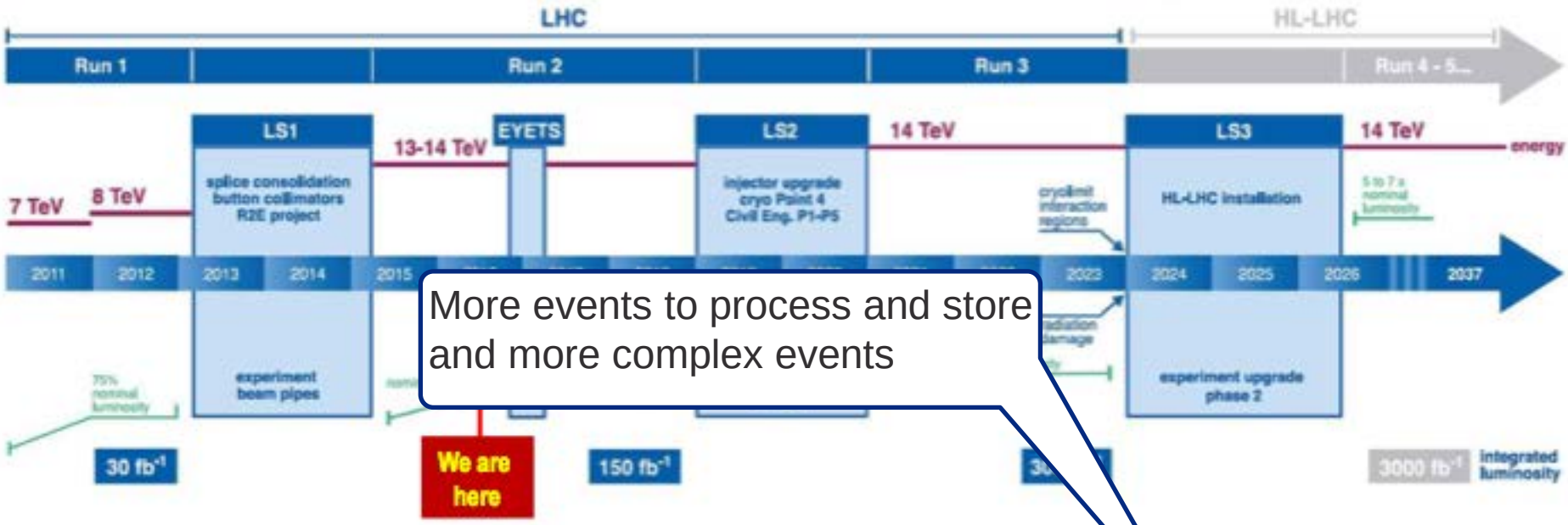
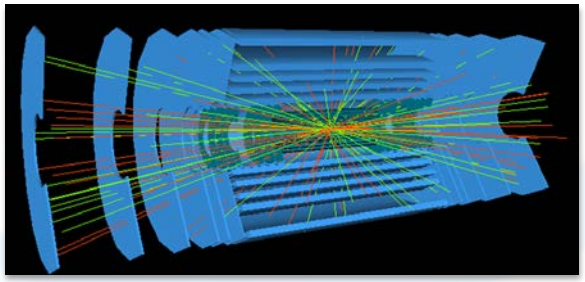


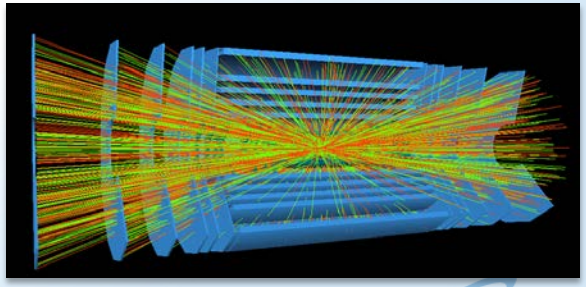
ATLAS and the LHC Program



More events to process and store and more complex events

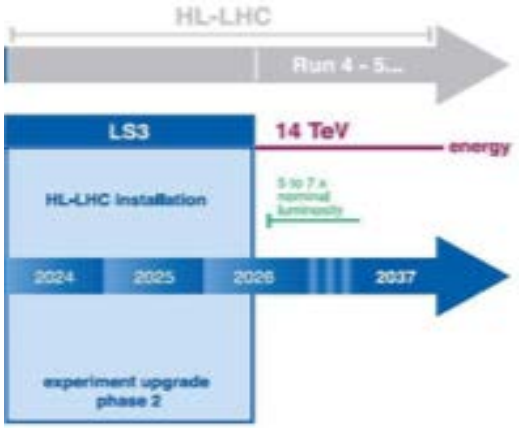
Trigger rate [kHz]	1	2	5-10
Number of events/bunch crossing	20	40	150-200





HL - LHC and the US

- High-Luminosity LHC (HL-LHC) project
  Approved June 2016
- A science program for the next 20 years



Building for Discovery

Strategic Plan for U.S. Particle Physics in the Global Context

usparticlephysics.org

The P5 Report provides a strategy and the priorities for U.S. investments in particle physics for the coming decade.

> **Start the High-Luminosity LHC (HL-LHC) accelerator and detector upgrade projects** so the U.S. can deliver its critical contributions on time. This is P5's highest priority near-term large project.

- **HL-LHC first priority of HEP program within the US**
- **DOE operates Tier 1**

U.S. LHC Detectors Operations:
Enabling the LHC Science Program

- LHC and corresponding detector operations are planned to be a central component of the U.S. program for next ~20 years
- U.S. objectives:
  - Meet U.S. CMS and ATLAS M&O common fund costs
  - Operate and maintain U.S. built detectors or detector components
  - Operate Tier-1s (DOE) and Tier-2s (NSF), contribute to the software tools
  - Enable U.S. physics analysis by providing computing support for analysis
  - Execute pre-project R&D for HL-LHC detectors upgrades in coordination with international funding agencies, collaborations, and CERN
- FY17 aim is to maintain level of U.S. LHC Operations according to the planned scope that U.S. ATLAS/CMS managements have discussed with DOE
  - Under a CR, close coordination between DOE and U.S. LHC Operations management will be necessary
- Aspects of international LHC Operations are supported in the U.S. under the Research program through the work of U.S. postdocs and graduate students
  - Impacts of past reductions to research budgets have led to "leakage" of some U.S. responsibilities to foreign groups
  - U.S. community needs to work with U.S. LHC Ops management to fulfill our objectives within overall allocated resources

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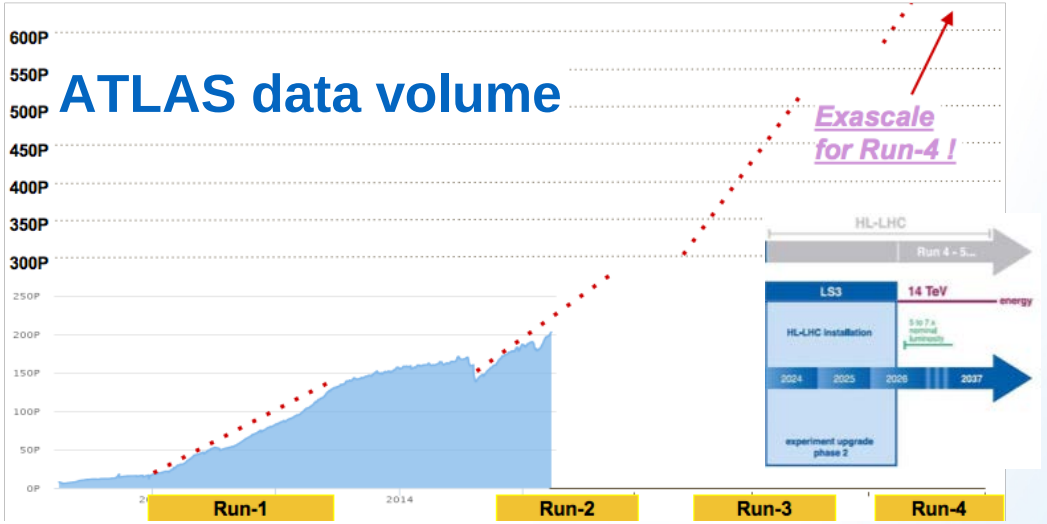
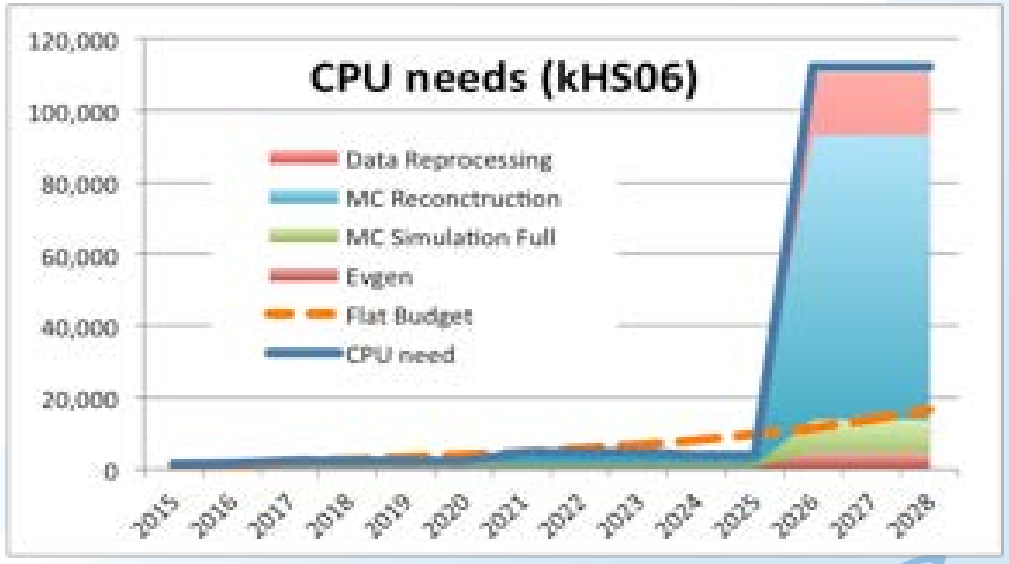
U.S.-CERN Cooperative Activities - July 2016 31

Computing Needs for HL-LHC

- Estimated computing needs beyond flat budget extrapolations :
  - Factor ~10 missing
  - Both for storage and computing
- A big challenge ahead
- US ATLAS Tier 1 at BNL has to host ~25% ATLAS computing capabilities





Existing RACF Issues and Limitations

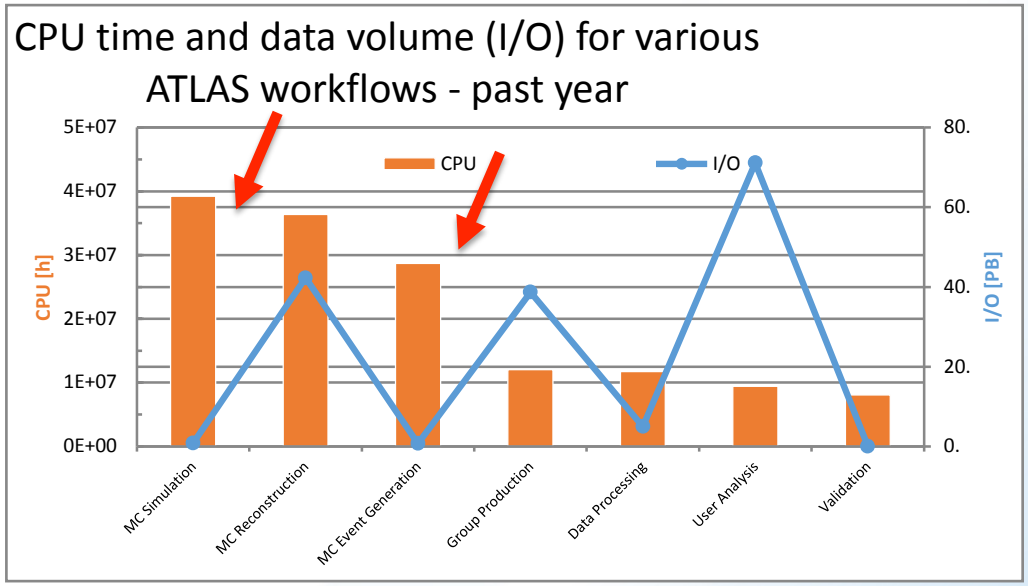
- Outdated existing (fragmented) Computer Center
  - Antiquated power distribution and cooling systems
  - Mismatch between available space, power and cooling in many locations
  - Inability to host future high density computing architectures
- Limited space
  - Just enough to meet RHIC/ATLAS needs until 2021
  - Operational cost
- No capability for growth
  - To meet HEP & NP programs needs beyond RHIC and ATLAS
  - To meet CSI mission requirements

Alternatives to New Building

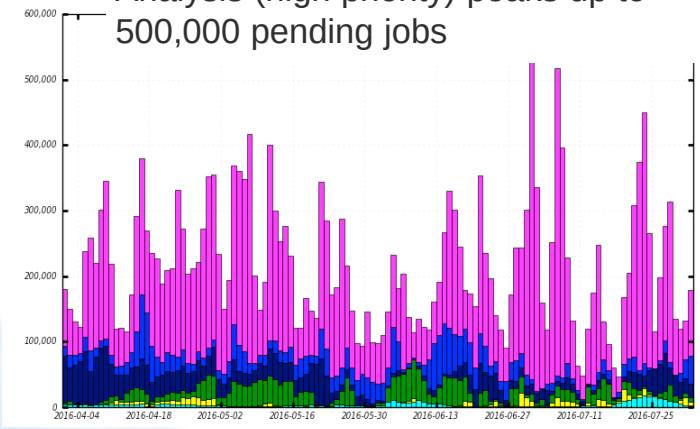
- **Stay within current building (B515)**
  - "+"
    - Lower cost
  - "-"
    - Long downtime : Refurbishing of power and cooling distribution systems, raised floors,…
    - Risk of major failure of infrastructure
    - Ability to meet PUE of 1.5 requirement (currently ~2) ?
    - No expansion capability
- **Cloud computing**
  - "+"
    - Postpone migration by externalization of some services
  - "-"
    - Storage on cloud is cost prohibitive and most of ATLAS workflows are too data intensive (need storage for input and output)
    - Transfer of data to/from cloud expensive
    - In-house computing less expensive
    - Potential volatility of cloud market, cannot be the only solution (how to go back?)
    - In-house computing can accommodate budget fluctuations
    - High priority tasks = high price

Cloud Services an Alternative?

- All ATLAS workflows are not suitable for Cloud Services
  - Only high CPU, low I/O and low priority workflows
  - Others workflows:
    - Too much I/O
    - Too high priority to benefit from Spot market prices



Analysis (high priority) peaks up to 500,000 pending jobs



- RACF is designed to meet these requirements

Cloud Services an Alternative?

- Price comparison for AWS vs in-house for ~10% current RACF capacity
- Conditions are biased toward cloud
  - Spot price for computing
  - Cost estimate over 3 years (equipments life time at RACF is usually 4-5 years)

- Over 3 years **cloud/in-house** (in-house includes electricity/space costs) at today's prices

  - Storage: ~3.6 Factor ($3.3M more for 7PB)
  - CPU (**Spot** market) : ~ 2 Factor ($0.6M more for 5k core)

Preliminary Migration Planning

- **Time window** : early FY21 (LHC shutdown & RHIC schedule)
- **Hypotheses/Assumptions** :
  - Work in CFR finished before start of LHC Run 3
  - B515 computing rooms operational after CFR completion
- **FY20** :
  - Installation of new storage equipment in CFR only
  - New data registered in CFR only
  - Replication of old data from B515 to CFR (2 copies: 1 in B515, 1 in CFR)
- **FY21** :
  - All data in CFR: switch off storage in B515, migrate hardware
  - Migration of CPUs (limited processing capacity for several months)
- **No complete shutdown of facility**
  - Exact details to be finalized
  - Data storage and availability guaranteed during migration

Core Facility Revitalization (CFR)

Critical Decision -1 (CD-1) Independent Project Review

Project Overview & Management

Peggy Caradonna, Project Director

Modernization Project Office

August 23rd – 25th, 2016

BROOKHAVEN NATIONAL LABORATORY

a passion for discovery

U.S. DEPARTMENT OF ENERGY | Office of Science

Core Facility Revitalization - CFR

- Committee Charge Questions

- Project Overview
  - Mission Need
  - Analysis of Alternatives
  - Conceptual Design Scope / Preliminary KPP's
  - Cost Range / Funding Profile
  - Preliminary Schedule Milestones
  - Project Management Organization
  - Acquisition Strategy
  - Project Management Processes / Documentation

- CD-1 Document Status

CFR – Committee Charge

- Have performance requirements been appropriately and sufficiently defined for this stage of the project?
- Has a credible and sufficient alternatives analysis been performed? Are project risks identified and has a credible Risk Management Plan been developed?
- Are the estimated cost and schedule ranges supporting the alternative credible and realistic for this stage of the project. Are scope, schedule and cost contingency adequate?
- Is the project being appropriately managed? Is the Integrated project Team established and functioning?

CFR – Committee Charge

- Are environment, safety, and health aspects being properly addressed given the projects current stage of development? Are Integrated Safety Management Principles being followed?

- Are project documents (e.g., AS, PPEP, PHAR) complete and ready for approval? Is the project ready for CD-1?

- Is the abatement of residual hazardous materials within B725 technically feasible, and if so, is abatement scope appropriately bounded in the alternatives analysis and cost and schedule ranges?

CFR – Mission Need

- **Mission Gap: RACF computing facility challenges**
  - Constructed in 1960's: Limited space, limiting configuration and antiquated power distribution and cooling systems
  - It is functionally obsolete relative to the ability to meet near term power, cooling, and reliability requirements
  - A more robust data center infrastructure is required

- **Cooling Infrastructure Deficiencies**
  - Single source of chilled water for cooling – fed from laboratories CUP
  - Cooling equipment is not on UPS
  - "Chaos cooling" practices – inefficient and wasted energy

CFR – Capability gaps

- **B515 Limiting Layout & Configuration**
  - Raised floor - 12” deep and highly congested
  - No staging space
  - Space constraints prevents reconfiguration of cooling equipment and Power Distribution Units (PDU)’s to accommodate ever increasing power rack densities w/o interruption to the systems running 24/7
    - service availability of 99% as required by MOU

CFR – Capability gaps

- **B515 Power System Deficiencies**
  - Lack of sufficient UPS power distribution & in some areas of the RACF, the facility is solely on utility power with no redundancy
  - The power distribution system is outdated and has no capacity for growth

Mission Need Statement (MNS) Approved 9/1/15:

To provide mid-range computational and data storage support to current and planned particle physics experiments at both RHIC and the ATLAS detector at CERN

CFR – Analysis of Alternatives

- **(5) Categories of Alternative Strategies Identified:**

Do Nothing

a. RACF remains in B515

Utilize Existing BNL Facilities

a. Expand and Renovate B515 (The existing RACF)
b. Renovate B725
c. Consider other BNL facilities for renovation

Construct New Facility (Line Item)

a. Construct a new facility at BNL, demo *equivalent* SF
b. Construct a new facility at BNL, demo B725

Construct New Facility (Alternative Financing)

a. Solicit private development and lease-back of a new facility adjacent to the BNL site

Establish Capacity at Another Location

a. Consider other laboratories, agencies, and/or Institutions
b. Consider Cloud Services

CFR - AoA

- **Preliminary Evaluation of Alternative Strategies:**
  - **Do Nothing**
    - Do not address the capability gap
  - **Utilize Existing BNL Facilities**
    - Expand and Renovate B515 (existing RACF)
      - Pros: Moderate initial cost.
      - Cons: Limited physical configuration (size/layout) and power/cooling capabilities. Significant/unacceptable interruption/shutdown to programs. Will not meet Exec. Order 13693
    - Renovate B725
      - Pros: Lowest initial cost, fastest project delivery. Capitalization of existing infrastructure and space. Will meet Exec. Order 13693
      - Cons: None

CFR - AoA

- **Preliminary Evaluation of Alternative Strategies (Cont.):**
  - **Utilize Existing BNL Facilities (cont'd)**
    - Consider other BNL facilities for renovation (B462, B477)
      - Adequate quantity & quality space does not exist on site
  - **Construct New Facility (Line Item)**
    - Construct a new facility at BNL, demo *equivalent SF*
      - Pros: New facility. Meets Exec. Order 13693
      - Cons: High total cost. B725 remains vacant with ongoing operational costs. Long delivery schedule. Requires office space to be constructed for occupants
    - Construct a new facility at BNL, demo B725
      - Pros: New facility ideally located with respect to key research facilities. Meets Exec. Order 13693
      - Cons: Highest total cost. Longest delivery schedule. Requires office space to be constructed for occupants

CFR - AoA

- **Preliminary Evaluation of Alternative Strategies (Cont.):**
  - **Construct New Facility (Alternative Financing)**
    - Solicit private development and lease-back of a new facility adjacent to the BNL campus
      - Pros: Low initial cost
      - Cons: Significant costs for facility/tenant fit out. Requires OMB approval
  - **Establish Capacity at Another Location**
    - Consider other laboratories, agencies, and/or Institutions
      - Pros: Lower initial cost
      - Cons: Infrastructure, space, and hardware is not available at this time at other institutions without significant investment at the respective sites. High risk with respect to outsourcing of operational responsibilities (MOU)
    - Consider Cloud Services
      - Pros: Cloud services have future potential to satisfy short term processing needs with limited SPOT services
      - Cons: SPOT services are volatile. Cost for data storage/compute services is high. Demonstrated very poor performance with input/output intensive scientific applications during BNL R&D. Cons are consistent with the findings of The Magellan Report on Cloud Computing for Science

CFR – LCCA / AoA

- Completed detailed LCCA on the following alternatives:
  - **Do Nothing**
  - **Utilize Existing BNL Facilities**
    - Renovate B725
  - **Construct New Facility (Line Item)**
    - Construct a new facility at BNL, demo equivalent SF
- Addressed in AoA
  - Construct New Facility (Alternative Financing)
  - Cloud Services

CFR – LCCA Results

	Alternative 1 Maintain Status Quo (Base Case)	Alternative 2 Renovate Existing Facility	Alternative 3 Construct New Facility
Total Life Cycle Cost	$109,328,869	$125,182,303	$148,144,853

	Alternative 2 Renovate Existing Facility	Alternative 3 Construct New Facility
Capital Investment	$67,922,000	$106,141,000
Net Cost Saving vs. Do Nothing	-$15,853,434	-$38,815,984
Simple Payback	25 years	>25 years
Adjusted Internal Rate of Return	0.75%	- 0.53%

- Alternative 2 life cycle cost is **$23M** less than Alternative 3
- Sensitivity Analysis had no effect on LCCA result

CFR – AoA Cloud Analysis Overview

	Storage (10% of existing requirements)	Compute (10% of existing requirements)
Amazon Web Services	$4,620,000	$1,178,707
In-house Services	$1,296,000	$580,500

Cloud vs. In-house

- Cloud storage more expensive by a factor of 3.6
- Cloud CPU more expensive by a factor of 2
- Only accounts for costs to host the data
  - Excludes costs to transfer and routine access of the data
- Unsatisfactory in terms of performance

CFR – Recommended Alternative

Preferred Alternative – Renovate B725

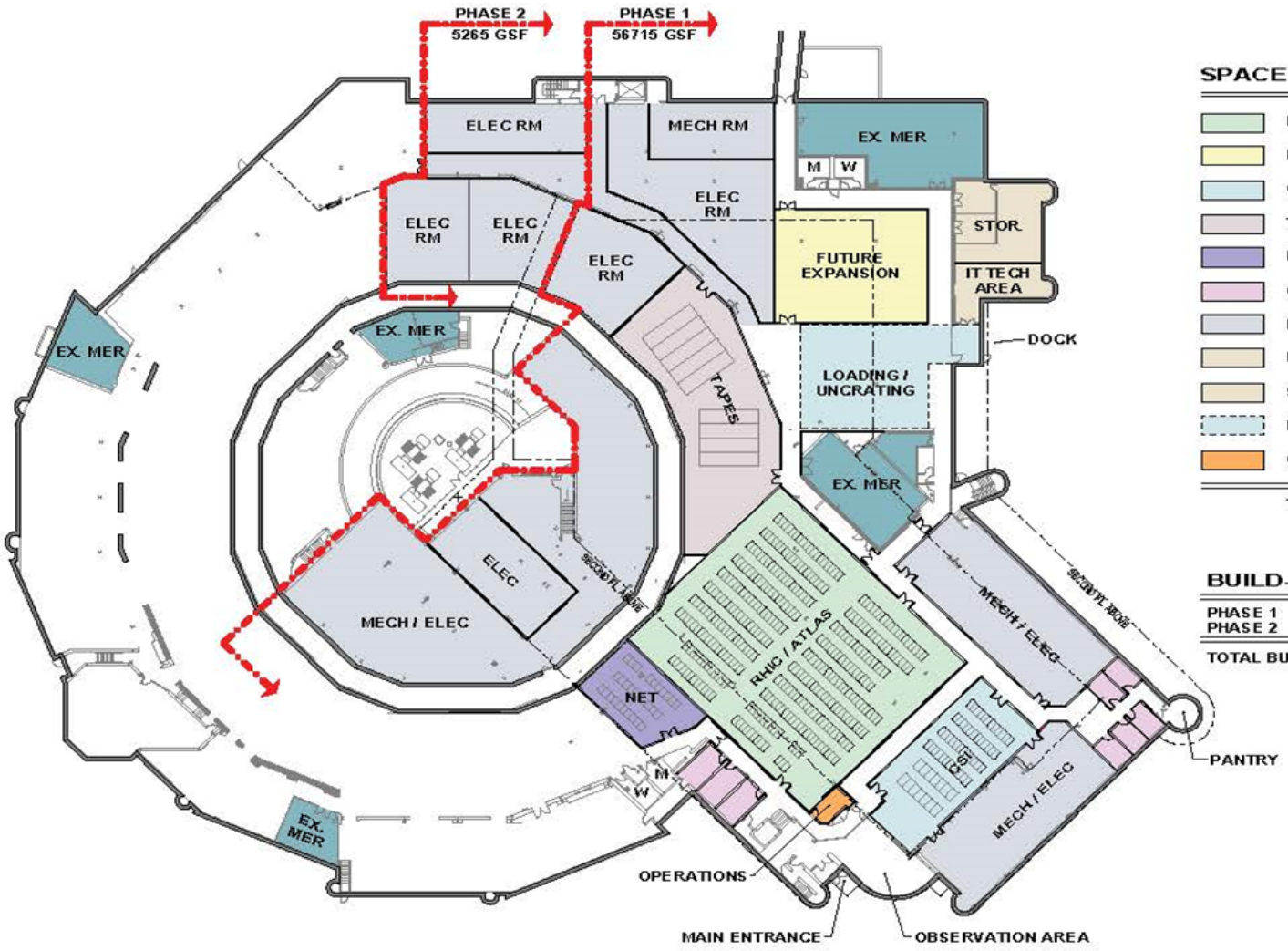
- Lowest life cycle cost vs. new construction
- Lowest TPC
- Earliest delivery schedule
- Capitalize on existing infrastructure
  - Structurally sound (Constructed 1980's with additions through 1995)
  - Robust Utilities (Electric & CW)
  - Contains existing quality office and conference space
- Sufficient area to provide for *future incremental growth opportunities* in terms of power/cooling and physical square footage.

CFR Overview - Scope

CFR Project Overview - Scope

- **Power:**
  - Initial capability (2021)- 2.4 MW IT Power & 1.2 MW Bypass
  - Switchgear, generators, UPS/Flywheel, internal power distribution
  - Provision for incremental growth (provision for three future1.2 MW IT power deployments)
  - Compliance with sustainability goals in Executive Order 13693
- **Cooling**:
  - Provide cooling infrastructure and back up capabilities to support 2.4 MW IT power facility with provision for incremental growth
  - New Chillers, cooling towers & air distribution system
  - Secondary chilled water service (for back-up)
- **Architectural**:
  - Federal High Performance Sustainable Building (HPSB) Requirements
  - Base design currently targets a LEED silver rating.
  - High performance roofing and exterior glazing systems
  - Raised floors, new ceilings, new lighting, new finishes
- **Life Safety**
  - New fire suppression and detection systems
  - Emergency lighting, lightning protection

CFR Overview – Conceptual Design Floor Plan



SPACE LEGEND

	PROGRAM NET AREA (NSF)	DELINEATED AREA (NSF)
RHIC / ATLAS	10800	9271
FUTURE EXPANSION	3450	2988
CSI	1950	2238
TAPES	3800	4159
NETWORK EQUIPMENT	1000	1196
OFFICES	1930	1196
MECH/ELEC	20200	28804
IT TECH AREA	500	643
STORAGE	1200	1200
LOADING / UNCRATING	560	2579
OPERATIONS	150	132
TOTAL NET AREAS	48590	54495

BUILD-OUT AREAS

	AREA (GSF)
PHASE 1	56715
PHASE 2	5265
TOTAL BUILD-OUT AREA	61980

0 16 32

N

DATE:	01 AUGUST 2016
PROJECT:	CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE:	ARCHITECTURE
SHEET:	2.4.1.2 FIRST FLOOR PLAN

BROOKHAVEN NATIONAL LABORATORY

HDR

CFR Overview – PPEP KPP's

CFR Preliminary Key Performance Parameters (KPPs)

Threshold KPP	Objective KPP
2.4 MW IT Power	2.4 MW IT Power
1.2 MW Emergency Back-up Capability	2.4 MW Emergency Back-up Capability

CFR Overview – Cost Range

	Low Range $K	High Range $K
Total Project Cost (TPC)	$64,474	$77,496

- Differences in cost range are attributable to scope assumptions, professional fee assumptions, differences in escalation and contingency assumptions

- CFR Design "Optimal Build-out"

TPC: $67.9M
20% contingency
11% scope contingency

Estimated EDIA : approx. 21%. (consistent with past projects)

CFR Overview – Preliminary Funding Profile

Preliminary Funding Profile ($K)

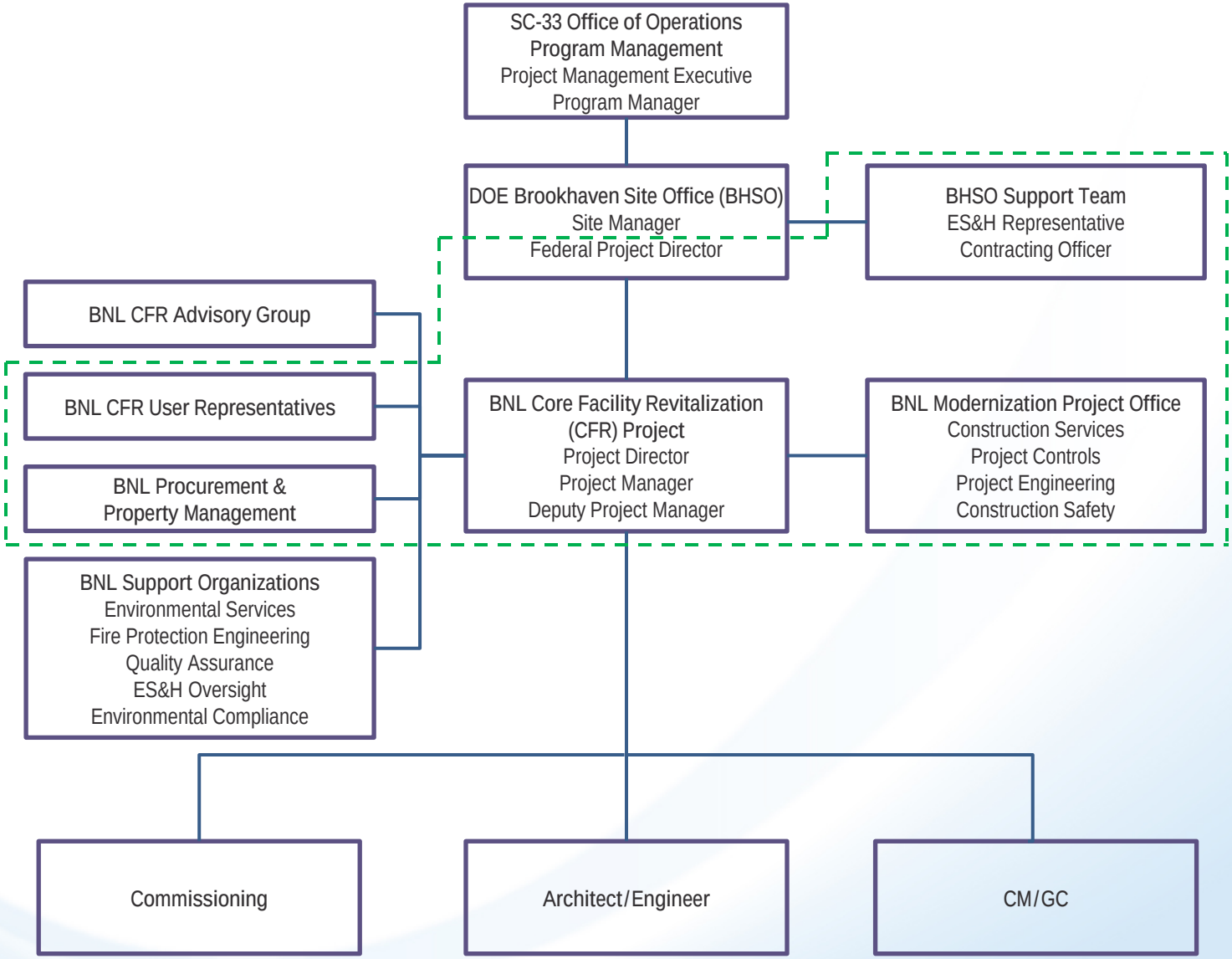
	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	Total
OPC	$850					$850
TEC PED		$1,800	$5,200			$7,000
TEC Construction			$10,000	$30,000	$20,023	$60,023
Total Project Cost	$850	$1,800	$15,200	$30,000	$20,023	$67,873

CFR Overview – Preliminary Milestone

Level	Milestone Description	Date
1	**CD-0 Approve Mission Need**	**September 2015 (A)**
1	**CD-1 Approve Alternative Selection and Cost Range**	**4Q FY16**
2	Award A/E Design Contract	**1Q FY18**
2	Award CM/GC Pre-construction Services – Phase 1	**2Q FY18**
2	Complete Preliminary Design (30%Documents)	**3Q FY18**
1	**CD-2/3A Approve Performance Baseline / Start Early Site Preparation Activities**	**3Q FY18**
2	Complete Final Design	**1Q FY19**
3	Start Site Preparation Activities	**3Q FY18**
1	**CD-3 Approve Start of Construction**	**1Q FY19**
3	Award CM/GC Construction Services – Phase 2	**1Q FY19**
2	Start Construction – Issue NTP	**1Q FY19**
2	Construction Substantially Complete	**3Q FY20**
1	**CD-4 Approve Project Completion**	**4Q FY21**

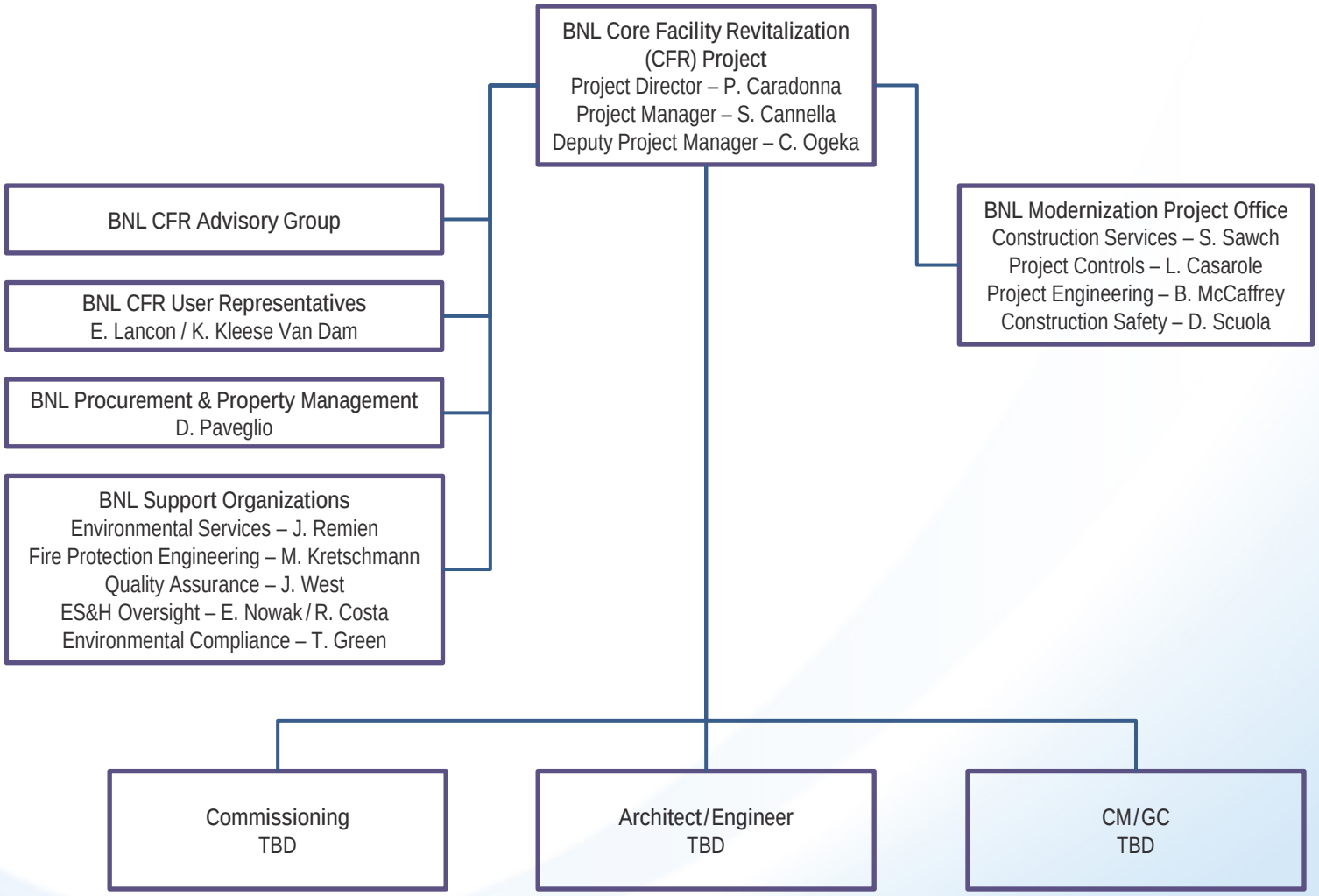
- Preliminary Early Finish: CD-4 4Q FY2020
- Preliminary Baseline: CD-4 4Q FY2021 12 months Schedule contingency ,1 year CR (FY17) 3 mo. CR (FY18)

CFR Project Organization Chart



IPT is identified by dashed lines

CFR Project Team Membership Chart



CFR – Project Management

- **Experienced project team in place**
  - Successful recent SLI projects: ISB, RSL-I, RSL-II
  - PD & PM - approximately 40-45 years combined experience, both DOE, federal and non-federal projects

- **CFR Staffing Level**
  - Project Director - .3 FTE
  - Project Manager- 1.0 FTE
  - Deputy Project Manager - .5 FTE
  - Project Controls Specialist - .33 FTE
  - Construction Engineer - 1.0 FTE
  - Construction Safety Engineer - .75 FTE
  - Field Support/Engineering Support – Approx. 2.0 FTE

CFR – Acquisition Strategy

- **HDR Architects selected for CDR and AoA/LCCA**
  - Significant DOE/BNL Experience
  - Significant Data Center/Critical Facility Design Experience
  - Local Cost Estimating services
  - Completed CFR Preliminary Programming Study 2015
- **Engineering & Design**
  - AE Services – Best Value source selection, Fixed price, design to cost
    - Preliminary & Final Design
  - Other consultants will be retained based on expertise
- **Construction**
  - Construction Manager/General Contractor (CM/GC) project delivery method with Best Value source selection
    - Phase I – Firm fixed price pre-construction services
    - Phase II (Optional) – Firm fixed price for construction

CFR – Acquisition Strategy

- **CM/GC – Preconstruction Services Phase**
  - Cost estimating (30/60/90/100)
  - Constructability reviews / feasibility studies
  - Industry outreach – market conditions/subcontractor availability
  - Value engineering
  - Scheduling and planning services
  - Subcontractor Bidding
- **CM/GC – Construction Phase**
  - General Contractor responsible for coordination, supervision and execution of all work
  - Job site safety oversight
  - Quality

CFR – Project Management

- **Established programs in BNL's Standards Based Management System.**
  - **Quality Assurance**
    - Design/code compliance / constructability / ES&H / Security / O&M reviews
    - Inspections during construction to ensure compliance with contract documents
    - BORE for Transition to Operations

      Successful BORE = Substantial Completion
    - Quality Assurance program flows down to all subcontracts

  - **Integrated Safety Management**
    - ISM forms the framework of the construction safety program and is flowed down contractually to all sub contractors
      - Define work, Identify Hazards & establish controls
      - Perform work & provide feedback

CFR – Project Management

- **Established programs in BNL's Standards Based Management System.**
  - **EVMS**
    - Certified Earned Value Management System
      - Guidelines, implementation requirements & processes are outlined in SBMS
    - Project Team has significant EVMS CAM & Project Controls experience on successful Line Item projects. Proven experience with tools, reporting and processes

CFR – Project Management

- **NEPA**
  - Project complies with all National Environmental Policy Act (NEPA) requirements. Categorical exclusion issued 6/23/16

- **Security & Vulnerability Assessment is complete**
  - Existing policies & procedures will remain in place

- **Risk Management Plan & Registry is complete**
  - Experienced Risk Management Team in place
  - Lessons Learned from prior BNL projects incorporated
  - Total of 31risks identified
  - Adequate cost and schedule contingency

- **Preliminary Hazard Analysis Report is complete**
  - -Hazardous are typical for conventional renovation projects
  - -Hazards related to future use of the facility mirror those within the existing RACF

CFR CD-1 Document Status

Prerequisite	Reference	SC-28 Decision Matrix Responsibility	Status
Prior to CD-1 Requirements			
1. Approve Acquisition Strategy	**DOE O 413.3B, Table 2.1, DOE G 413.3-13**	Reviewed by SC-28 Approved by SC-AD	**95% - Post Draft for IPR**
2. Approve Preliminary Project Execution Plan (PEP) – Approve a PEP (Tailoring Strategy, if required, can be included in the PEP	**DOE O 413.3B, Table 2.1, DOE G 413.3-15**	Reviewed by SC-28 Approved by SC-AD	**95% - Post Draft for IPR**
a. Approve appointment of Federal Project Director	**DOE O 361.1B**	SC-AD	**In Progress**
a. Approve and establish and charter an Integrated Project Team to include a responsibility assignment matrix. The Charter may be included in the PEP	**DOE O 413.3B, Table 2.1, DOE G 413.3-18**	SC-AD	**Complete**
a. Develop a Risk Management Plan (RMP) and complete an initial risk assessment of a recommended alternative. (This may be included in the PEP)	**DOE O 413.3B, Table 2.1, DOE G 413.3-7**	Brookhaven Science Associates	**Complete**
3. Comply with the One-for-One Building Space Replacement (excess space/offset requirement)	**DOE O 430.1B, House Report 109-86**	Brookhaven Science Associates	**Complete**
4. Complete a Conceptual Design	**DOE O 413.3B Appendix C, Paragraph 4**	Brookhaven Science Associates	**Complete**
a. Document High Perf. & Sustainable Bldg. & Sustainable Env. Stewardship considerations in the Conceptual Design Report, Acquisition Strategy, and/or PEP, as appropriate.	**Per EO 13693, Section 3 (h) (i-iv) and DOE O 450.1A, DOE G 413.3-6 and DOE O 430.2B**	Brookhaven Science Associates	**Complete**
a. Conduct a Conceptual Design Review (Director's Review)	**DOE O 413.3B, Table 2.1**	Team external to Project	**Complete**
a. Complete a Conceptual Design Report	**DOE O 413.3B, Table 2.1 and Appendix C, Paragraph 4**	Brookhaven Science Associates	**Complete**
5. Prepare a Preliminary Hazard Analysis Report	**DOE O 413.3B, Table 2.1**	Brookhaven Science Associates	**Complete**
6. Develop and Implement an Integrated Safety Management Plan	**DOE O 413.3B, Table 2.1, DOE M 450-1**	Brookhaven Science Associates	**Complete**
7. Establish Preliminary Quality Assurance Program (QAP)	**DOE O 413.3B, Table 2.1, DOE O 414,1C and DOE G 413.3-2**	Brookhaven Science Associates	**Complete**
8. Identify general Safeguards and Security requirements for the recommended alternative	**DOE O 413.3B, Table 2.1, DOE M470.4-1 and DOE G 413.3-3**		**Complete**
9. Complete National Environmental Policy Act (NEPA)Strategy by issuing a determination (i.e., EIS, EA)	**DOE O 413.3B, Table 2.1 and DOE O 451.1B**	Brookhaven Science Associates	**Complete**
10. Conduct Independent Project Review or External Independent Review		SC-28	**Scheduled**
11. Update PDS, or other funding documents for MIE and OE projects, and OMB 300s, if applicable.	**OMB Budget call for PDS and Exhibit 300 Template**	SC-AD	**In Progress**

Success Starts With A Strong Safety Culture

- In conjunction with the Lab's ISM program, we have a strong safety culture at BNL
  - Everyone is personally responsible for ensuring safety
  - We "own" our work, deliver it, do what we say we will do and expect others to do the same
  - We cultivate a questioning attitude
  - Learning never stops
  - Hazards are identified and evaluated for every task, every time
  - A healthy respect is maintained for what can go wrong.

Independent Project Reviews are opportunities to challenge our assumptions and reinforce what is right.

CFR – Summary

- ✓ Performance requirements been appropriately and sufficiently defined for this stage of the project.
- ✓ A credible and sufficient alternatives analysis has been performed.
- ✓ Project risks are sufficiently identified and a credible Risk Management Plan and Registry have been developed.
- ✓ The estimated cost and schedule ranges supporting the alternatives are credible and realistic for this stage of the project. Scope, cost, and schedule contingency is adequate.
- ✓ The project is being appropriately managed. The project team is experienced and dedicated. The Integrated Project Team is established and functioning.

CFR – Summary

- ✓ Environment, safety, and health aspects have been properly addressed given the projects current stage of development. Integrated Safety Management Principles are being followed.
- ✓ Project documentation is complete and ready for approval.
- ✓ The abatement of residual hazardous materials within B725 is technically feasible. The abatement scope is appropriately bounded in the alternatives analysis and cost and schedule ranges.

The project is ready for CD-1 approval.

Core Facility Revitalization (CFR)

Critical Decision -1 (CD-1) Independent Project Review

Project Scope, Cost, and Schedule

Steven Cannella, Project Manager
Modernization Project Office
August 23rd – 25th, 2016

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Core Facility Revitalization - CFR

- CFR Scope
  - Performance Requirements
  - Conceptual Design
  - Sustainability – High Performance Sustainable Buildings
- Analysis of Alternatives
- Work Breakdown Structure
- CFR Cost Range
- Risk Management
- Project Tailoring
- CFR Preliminary Schedule
- Lessons Learned

CFR – Performance Requirements

Performance requirements are appropriately defined to address the identified *capability gaps* and support Mission Need:

- **515 Limiting Layout & Configuration**
  - Provide large/open computing floor areas
  - Provide appropriate (30”) raised floor systems
  - Provide flexible power/data distribution systems
  - Provide for incremental growth opportunities
- **515 Cooling Infrastructure Deficiencies**
  - Provide new, modern, and efficient cooling systems
  - Provide back-up chilled water service and air handling capabilities
  - Employ state of the art air management strategies (Hot aisle containment system) to meet sustainability goals
  - Provide for incremental growth opportunities

CFR – Performance Requirements

- **515 Power System Deficiencies**
  - Deploy an IT power strategy to satisfy day-one power requirements with adequate provision for short and long term growth and expansion while meeting sustainability goals
  - Provide enhanced reliability through deployment of UPS and back-up power generating systems. Provide a by-pass power system to allow for concurrent maintenance
  - Provide for incremental growth opportunities
- **Inadequate/Limited Physical Space**
  - Leverage BNL strengths in data-centric and high-throughput computational science to take advantage of efficiencies and productivity gains by co-location of the computational staff and their resources to a new, state of the art, modern facility
  - Roof replacement, window replacement, life safety upgrades

CFR – Conceptual Design

(3) Distinct sets of design drivers identified…

1. Power, Cooling, and Reliability Requirements

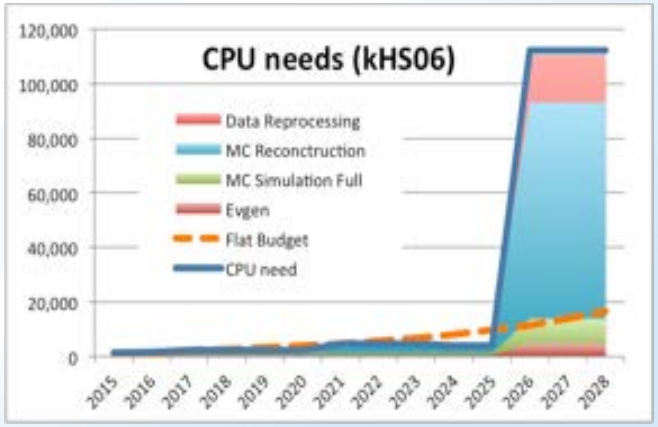
- User/Program Generated Power, Cooling, and Reliability Requirements (ATLAS Service Agreement)

2. Mandates – Efficiency and Metering

- E.O. 13693 – Planning for Federal Sustainability in the Next Decade & Data Center Optimization Initiative (DCOI)
  - PUE Requirements
  - Automated Infrastructure Requirements
  - Advanced Metering/monitoring

3. Flexibility

- Incremental growth and expansion capabilities
  - Power
  - Cooling
  - Physical expansion/growth



HL-LHC Computing – 6/2016

CFR – Conceptual Design

Power, Cooling, and Reliability Requirements

- **User Generated Requirements**
  - Key Stakeholders: RACF/CSI (SDCC)
  - Programming study completed September 2015
  - Conceptual Design finalized August 2016
    - User workshops
    - Design charrettes
    - Field work
- **ATLAS Service Agreement**
  - BNL serves as the US Tier 1 computing facility for the ATLAS experiment at the LHC. The only such facility in the US and the largest in the world.
  - Service Level Agreement – 99% annual average uptime, = 3.5 days allowable downtime
  - HL-LHC commitment – Expectations increasing!

CFR – Conceptual Design

PHASE I @ INITIAL CONSTRUCTION									
User	Platform	Rack/ Cabinet Quantity	Load per Rack/ Cab. (kw)	Total Load (kw)	% by DAE	% by CHW	DAE Load (kw)	Direct CHW Cooled Load (kw)	Chw Plant Capacity with 87% for DAE's (tons)
RHIC/ATLAS									
	x86	200	8.0	1,600	100%	0%	1,600	0	396
Subtotal				1,600			1,600	0	396
CSI									
	Super Computer	0	100.0	0	0%	100%	0	0	0
	HPC	20	25.0	500	75%	25%	375	125	128
	x86	10	8.0	80	100%	0%	80	0	20
Subtotal				580			455	125	148
NETWORK									
		30	3	100	100%		100	0	
Subtotal				100			100	0	25
TAPE									
		12	15	180	100%		180	0	
Subtotal				180			180	0	45
Sub-Totals		**272**		**2,460**					
Grand Total (kW)							**2,335**	**125**	**2,460**
Grand Total (tons)									**613**

CFR – Conceptual Design

ULTIMATE LOAD @ BUILD OUT									
User	Platform	Rack/ Cabinet Quantity	Load per Rack/ Cab. (kW)	Total Load (kW)	% by DAE	% by CHW	DAE Load (kW)	Direct CHW Cooled Load (kW)	CHW Plant Capacity with 87% for DAE's (tons)
RHIC/ATLAS									
	x86	300	10	3,000	100%	0%	3,000	0	742
Subtotal				3,000			3,000	0	742
CSI									
	Super Computer	15	100	1,500	0%	100%	0	1,500	426
	HPC	40	25	1,000	75%	25%	750	250	257
	x86	15	15	225	100%	0%	225	0	56
Subtotal				2,725			975	1,750	739
NETWORK									
		30	3	100	100%		100	0	
Subtotal				100			100	0	25
TAPE									
		12	15	180	100%		180	0	
Subtotal				180			180	0	45
Sub-Totals		**412**		**6,005**					
Grand Total (kW)							**4,255**	**1,750**	**6,005**
Cooling Load (tons)									**1,550**

CFR – Conceptual Design

BNL 725 Space Requirements Tabulation

USER/FUNCTION	QUANTITY	UNIT AREA (S.F.)	AREA (S.F.)
DATA EQUIPMENT SPACE			
RHIC/ATLAS			10,800
CSI			1,950
Future Expansion			3,450
Local Network Equipment	1	1,000	1,000
Tape Storage Libraries	12	400	4,800
Subtotal			**22,000**
OFFICE AND OFFICE SUPPORT			
Private Offices	6	120	720
Shared Offices	6	192	1,152
Subtotal			**1,872**
FACILITY OPERATIONS			
Electrical Equipment Rooms			
Switchgear	6	450	2700
UPS	5	300	1500
Mechanical Equipment Rooms	5	750	3750
Air Handling Equipment Rooms	4	3,000	12,000
Fire Protection Equipment Rooms	2	125	250
Loading Dock	1	320	320
Uncrate and Assembly Area	1	240	240
IT Technician Area	1	500	500
Operations Office / Mantrap	1	150	150
Pantry	1	100	100
Subtotal			**21,510**
Total Net Area			45,382
Grossing Factor 25%			11,345
TOTAL AREA			**56,727**

CFR – Conceptual Design - Mandates

- **Data Center Optimization Initiative (DCOI)**
  - Effective August 1st, 2016. Supersedes the Federal Data Center Consolidation Initiative. Reinforces requirements of E.O. 13693 – "Planning for Federal Sustainability in the Next Decade" 3/19/2015
  - New optimization policy effects all new/existing federal data centers
  - New optimization targets (metrics) established and prioritized for compliance by end of FY18
- **Power Usage Effectiveness (PUE)**
  - PUE is a key metric
  - PUE = Total Facility Power / IT Power
  - For new facilities… no greater than 1.4, encourage targeting 1.2
- **Automated Infrastructure Management**
  - Required for automated infrastructure management and reporting
  - Advanced monitoring and metering requirements
  - Multiple vendors/sources exist

CFR – Conceptual Design

Data Center Infrastructure Management (DCIM)

- **IT Features**
  - Space planning
  - Rack planning and design
  - Asset Management
  - Capacity planning
  - Change management
  - Reporting Dashboard with KPIs
  - Virtualization and optimization
- **Facility Management Features**
  - Power metering and monitoring
  - Environmental monitoring
  - Real time PUE
  - Reporting Dashboard with KPIs

CFR – Conceptual Design

Flexibility – Incremental Approach

- **Power**
  - Day-one capability (2021) – 2.4 MW IT power (dedicated computing power). Approximately double current RACF IT power consumed.
  - Provide provision for future1.2 MW IT power increments to 6MW
- **Cooling**
  - Day-one cooling capability to support 2.4 MW IT power
  - Provide provision for future 1.2 MW IT power deployments
- **Physical Expansion**
  - Day-one – Allows for an approximately 33% footprint expansion (Racks) within defined spaces.
  - Day-one – Provide approximately 3,500 SF unfinished, unassigned space.
  - Provide opportunity for future (long term) growth within the balance of the 725 facility. Computing and/or offices.

CFR – Design Concepts

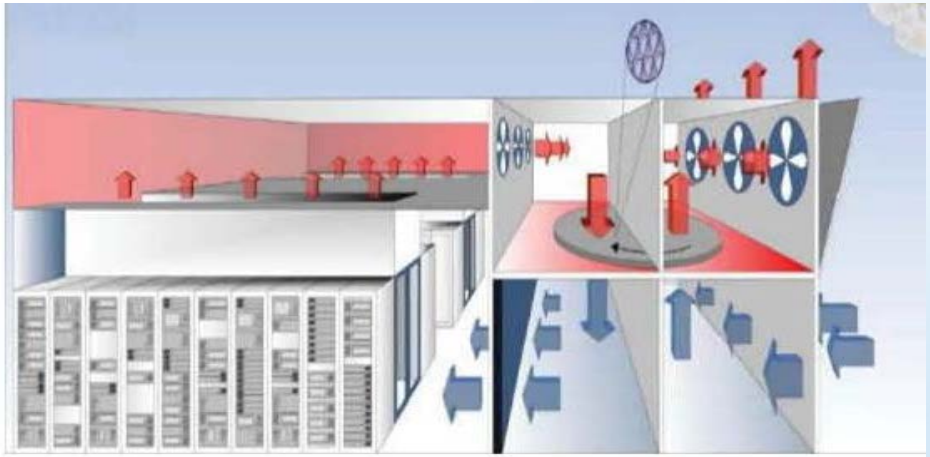
Hot Aisle Containment

- Integrated provisions for air path containment, cable trays, and power raceways/busway.
- Required due to increased power density.
- Higher return air temperature = higher operating efficiency (95 deg. “+”)

CFR – Design Concepts

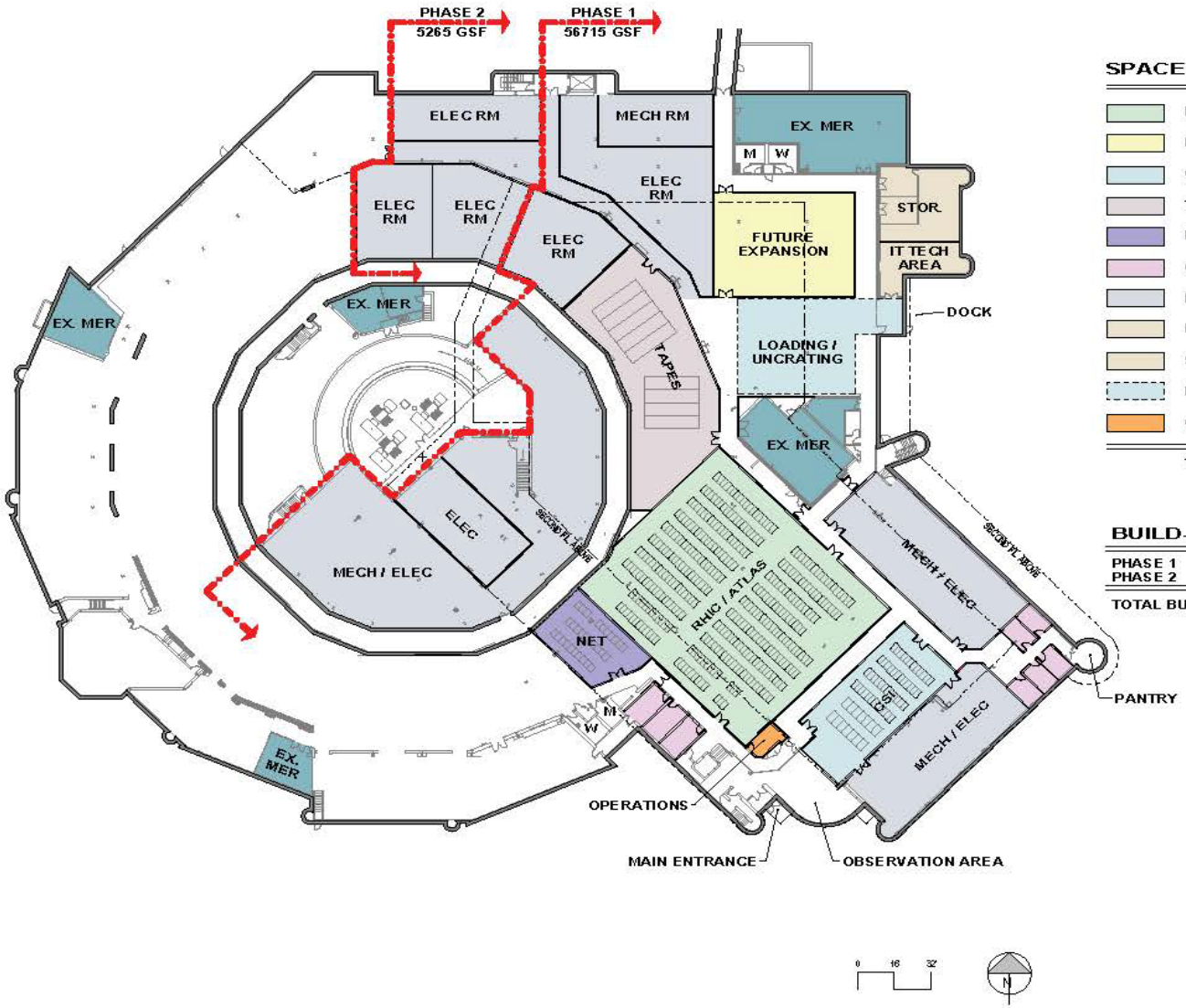
Air-side Economizer System

- Dry air economizers (DAE) leverage air-to-air heat exchange to provide cooling for a significant portion of the year
- Achieve a lower PUE.
- Augment with a chilled water system to provide “peak shaving”



Theory behind rotary heat exchanger technology

CFR – Schematic Floor Plan



SPACE LEGEND

	PROGRAM NET AREA (NSF)	DELINEATED AREA (NSF)
RHIC / ATLAS	10830	9271
FUTURE EXPANSION	3450	2953
CSI	1950	2233
TAPES	3500	4199
NETWORK EQUIPMENT	1000	1195
OFFICES	1000	1195
MECH/ELEC	20200	28594
IT TECH AREA	500	643
STORAGE	1200	1200
LOADING / UNCRATING	560	2579
OPERATIONS	150	132
TOTAL NET AREAS	43390	54496

BUILD-OUT AREAS

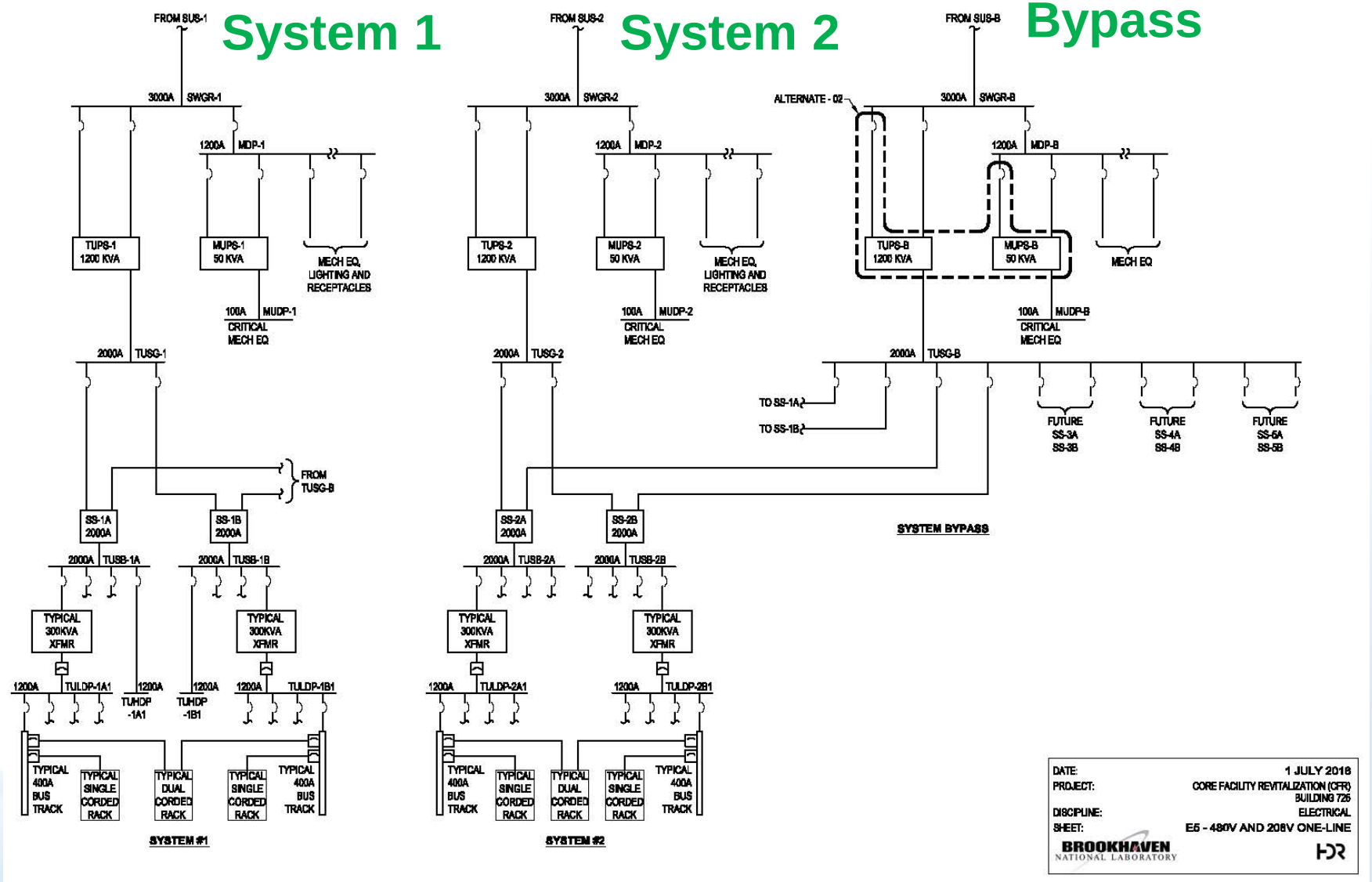
	AREA (GSF)
PHASE 1	56715
PHASE 2	5265
TOTAL BUILD-OUT AREA	61980

DATE:	01 AUGUST 2016
PROJECT:	CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE:	ARCHITECTURE
SHEET:	2.4.1.2 FIRST FLOOR PLAN

BROOKHAVEN NATIONAL LABORATORY

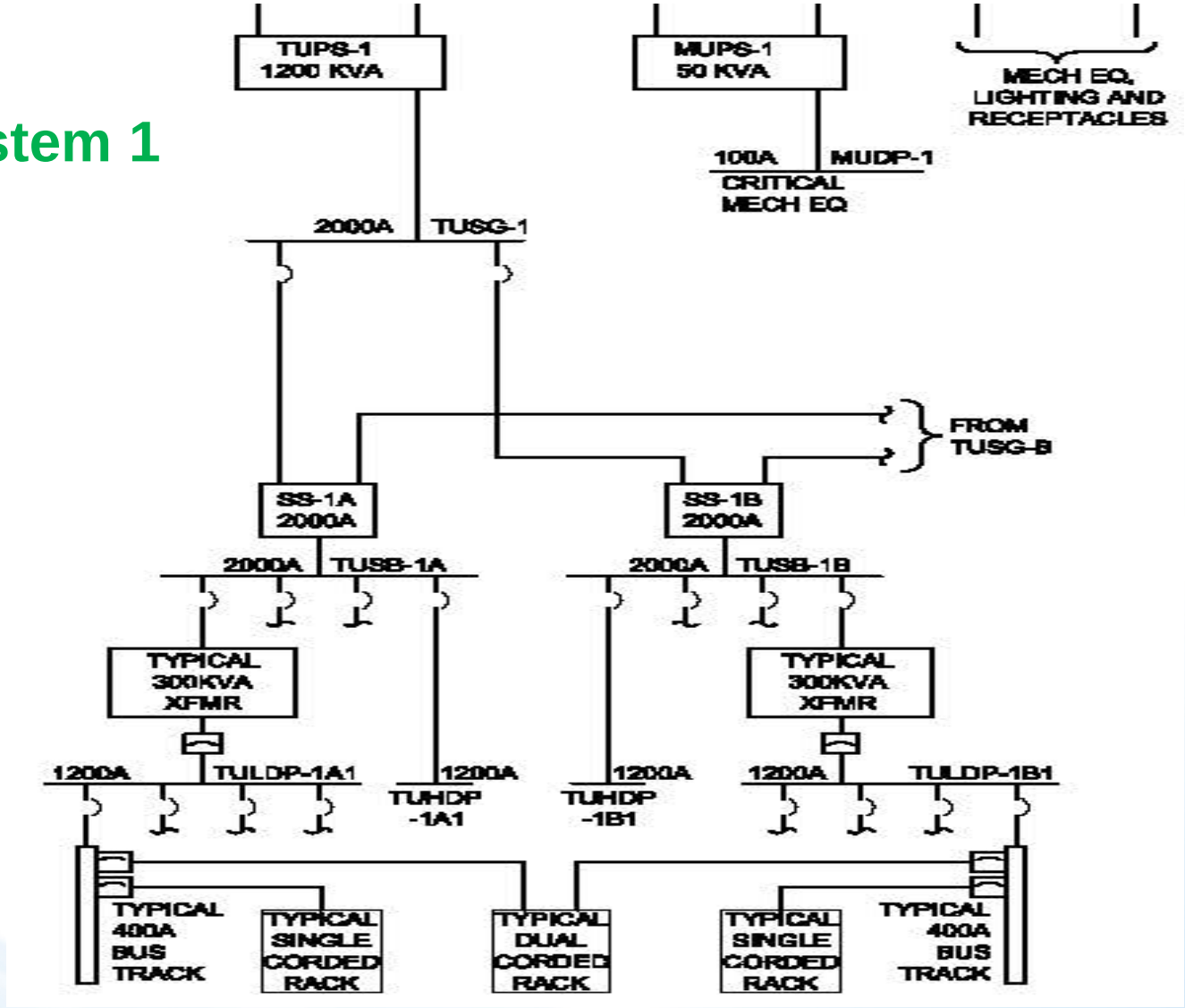
HDR

CFR – Electrical Schematic

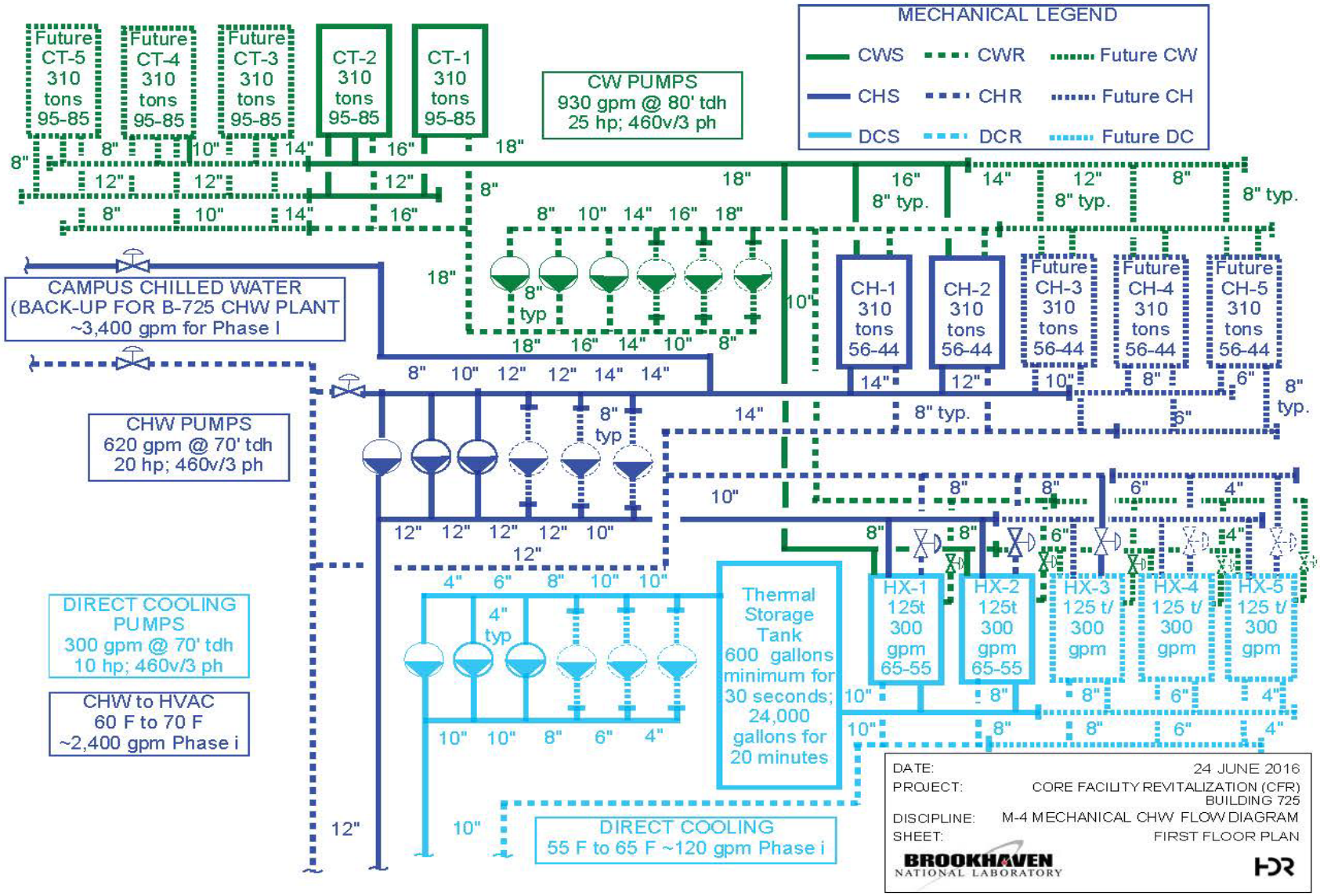


CFR – Electrical Schematic

System 1



CFR – Mechanical Schematic



CFR – Tailoring Strategy / Site Preparation

- **A CD-2/3A Strategy is proposed**
  - Early Procurements of Long Lead Equipment
    - Generators (2)
    - Air Handlers (11)
    - Cost = Approx. $7M
  - Early Site Preparation – Address Residual Lead
    - The B725 Hazard Removal Project (HRP) completed 3/31/16.
    - TPC = $7.4M. Overview presentation to follow…
    - CFR to complete balance of first floor residual lead remediation
    - Cost estimated March 2016, re-validated August 2016
    - Environmental consultant retained to complete scoping study
    - Cost Range: $1.0M - $2M (direct cost) “+” Project Mgmt. & Oversight.
    - $2M included in point estimate
    - Duration: Approx. 2.5 – 3 Months
  - FY18 Construction Funding Required

CFR – Tailoring Strategy / Site Preparation

B725 Lead Dust Remediation Strategy		
Field Condition	**Location(s)**	**Recommended Methodology**
Structural Concrete/Concrete Block	High Bay, Experimental Floor, Mechanical rooms, X-Ray Tunnel	HEPA Vacuum / Detergent wipe /Encapsulate
Painted Gypsum Walls	1st Floor	HEPA Vacuum / Detergent wipe
Floors - Bare Concrete	High Bay, Experimental Floor, Mechanical rooms	HEPA Vacuum / Detergent wipe /Encapsulate
Floors - VCT over Concrete	High Bay, Experimental Floor, Offices	Removal & Disposal / Encapsulate
Pipe/Duct Insulation	1st Floor	Removal & Disposal
Structural Steel	High Bay, Experimental Floor	HEPA Vacuum / Detergent wipe
HVAC Ductwork to Remain	1st Floor - Outside CFR Footprint	HEPA Vacuum / Detergent wipe
HVAC Ductwork to be removed	1st Floor - Within CFR Footprint	Removal & Disposal
Exposed Pipe and Conduit	High Bay, Experimental Floor, Mechanical rooms	HEPA Vacuum / Detergent wipe
Fabric Sound dampening panels	High Bay, Experimental Floor	Removal & Disposal
Fixed cabinetry/counters/fixtures	1st floor Labs, restrooms	HEPA Vacuum / Detergent wipe
Ceiling Tile	1st Floor Offices, Labs, restrooms, support spaces.	Removal & Disposal

CFR – Tailoring Strategy / Site Preparation

- **Site Preparation – Residual Lead**
  - Ductwork
    - Remove approx. 72,000 SF ($4/SF)
    - Clean approx. 44,000 SF ($6/SF)
  - Floors
    - Clean & encapsulate approx. 39,000 SF ($6/SF)
    - Remove VCT approx. 77,000 SF ($4/SF)
  - Bulk Lead ($150k)
    - X-17 Hutch
    - X-ray tunnel ceiling penetrations (approx. 65)
  - Ceiling tile
    - Remove approx. 10,000 SF ($4 SF)
    - Assumed all tiles hazardous at this time
  - Disposal
    - All waste assumed to be hazardous @ $400/ton
    - No allowance for recycling at this time (HRP = $700K)

CFR – Sustainability

- LEED v4 for BD+C: Data Centers Project Scorecard used to demonstrate potential certification level. Currently Silver. Certification is not required

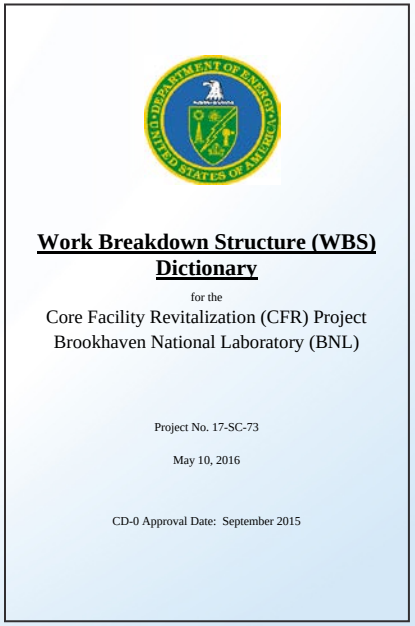
- Preliminary compliance with the guiding principles for Sustainable federal Buildings
  - For modernization – 19 of 21 pre-determined metrics required
  - Current status – 18 of 21 confirmed. #9 is a maybe?
  - #9 – Alternative Water: *Consider* sources of alternative water where cost effective and permitted by local laws and regulations

CFR – Sustainability

- **Sustainable Strategies**
  - Construction Activity Pollution Prevention
  - Indoor Water Use Reduction – low flow fixtures
  - Water Metering
  - Energy Metering – Advanced Energy Metering
  - Enhanced Commissioning
  - Optimize Energy Performance
  - Construction Recycling
  - Low-Emitting Materials
  - Construction IAQ Management
  - Interior Lighting controls / occupancy sensors

CFR – Work Breakdown Structure

- 1.0 Core Facility Revitalization (CFR)
  - 1.01 Project Design and Engineering
    - 1.01.01 A/E Preliminary and Final Design
    - 1.01.02 CMGC Pre-Construction Services
    - 1.01.03 Commissioning Pre-Construction Services
    - 1.01.04 Project Management – Pre-Construction Phase
    - 1.01.05 BNL/MPO Engineering Support – Pre-Construction Phase
  - 1.02 Construction
    - 1.02.01 Site Preparation Activities
    - 1.02.02 Building Construction
    - 1.02.03 A/E Construction Administration Services
    - 1.02.04 Commissioning – Construction Phase
    - 1.02.05 Project Management – Construction Phase
    - 1.02.06 Project Support – Construction Phase
      - 1.02.06.01 BNL/MPO Engineering Support – Construction Phase
      - 1.02.06.02 BNL Field Support – Construction Phase
  - 1.03 Other Project Costs (OPC)
    - 1.03.01 Conceptual Design



Work Breakdown Structure (WBS) Dictionary

for the

Core Facility Revitalization (CFR) Project
Brookhaven National Laboratory (BNL)

Project No. 17-SC-73

May 10, 2016

CD-0 Approval Date: September 2015

CFR – Cost Range

CFR Preliminary Key Performance Parameters (KPPs)

Threshold KPP	Objective KPP
2.4 MW IT Power 1.2 MW Emergency Back-up Capability	2.4 MW IT Power 2.4 MW Emergency Back-up Capability
$64.5M Low Cost Range	**$77.5M** High Cost Range
Potential Scope Contingency: System 1 Generator - ($1.49M) System 1 Chiller - ($.8M) Enhanced Roofing System/Leak Detection - ($1.55M)	Potential Scope Enhancements: Fit-out Approx. 3,500 GSF expansion Space - $1.79M Provide By-pass System Generator - $1.49M Refurbish Exterior Metal Panels - $.49M
Assumptions: 20% Total Contingency - $9.9M Cost Escalation @ 2%/Yr. AE Fees - 10% Const. Contract Reduced CM Fee/Commissioning Fee	Assumptions: 25% Total Contingency - $15.3M Cost Escalation @ 3%/Yr. AE Fees - 11.5% Const. Contract

CFR – Cost Range Summary

	Low Range K$	High Range K$
Total Estimated Cost (TEC)		
Preliminary and Final Design	$4,654	$6,335
Construction	$40,820	$50,281
Project Support	$4,348	$4,701
Direct TEC	$49,822	$61,317
Contingency (% TEC)	$9,964 (20%)	$15,329 (25%)
Scope Contingency (10% Const.)	$3,837	
Subtotal TEC	$63,623	$76,646
Other Project Costs (OPC)		
Conceptual Design - OPC	$850	$850
Total Project Cost (TPC)	$64,474	$77,496

- Differences are attributable to assumptions…
  - Range in AE / Commissioning fees (10-11.5%)
  - Cost escalation range (2-3% / yr.)
  - Contingency range (20-25%)
  - Scope enhancements / scope contingency
- Preliminary point estimate = $67,873K (TPC) representing “optimal” scope has been prepared to form the basis of the cost range.
  - 2.4 MW IT Power w/ By-pass system
  - 2.4 MW Emergency Back up power - (2) Generators
  - (2) 300T. Chillers w/ Back-up CW – Central Plant
  - Approx. 17,000 GSF computing floor area (ready for occupancy)
  - Approx. 3,500 GSF “future” computing floor area (unfinished)

CFR – Preliminary Funding Profile

	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	Total
OPC	$850					$850
TEC PED		$1,800	$5,200			$7,000
TEC Construction			$10,000	$30,000	$20,023	$60,023
Total Project Cost	$850	$1,800	$15,200	$30,000	$20,023	$67,873

The preliminary funding profile is aligned with projected spending

CFR – Risk Management

- The CFR Preliminary Risk Management Plan has been developed and the Risk Management Team established
  - Identify and measure unknowns & potential impact
  - Develop mitigation options
  - Plan and select risk mitigation strategy
  - Track implementation for successful risk reduction
  - Documents are posted for review

- Risk Management Team Includes representatives from:
  - DOE
  - Project Management
  - ES&H
  - Procurement
  - User Representatives
  - Construction Services

Team serves for the duration of the project

CFR – Risk Management

- Determine risk events by examining each project activity (WBS element) and process for possible root causes
- Project contingency developed using expert judgment by team members with significant credentials and similar project experience
- Preliminary evaluation by Monte Carlo Analysis complete
- The Risk Registry is a “living” document that will be updated throughout the life of the project
- Quarterly meetings with project risk management team and risk holders to review risks and update the registry

CFR – Risk Management

- 31 risks identified and evaluated that are common construction risks and are particularly unique to renovations
  - Working in occupied buildings
  - Working with existing building systems
  - Concealed conditions
  - Hazardous materials

- Preliminary Risk Analysis Results…
  - Recommend 8 months / Maintain 12 months
  - Recommend $7.4M / Maintain $11.2M

CFR – Risk Management

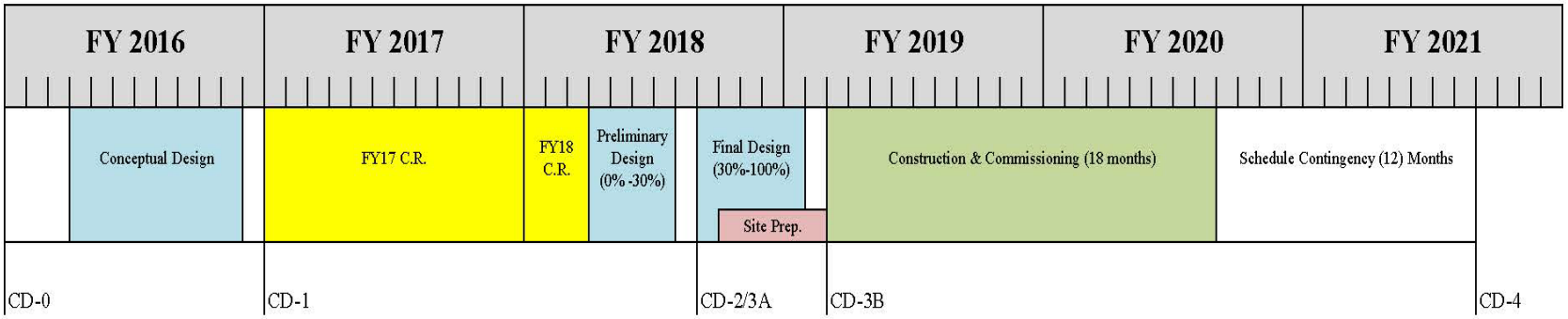
Risk	Mitigation Measure
User generated scope changes during construction (cost and Schedule)	Rigorous project controls, value engineering and pre-construction design reviews. Adequate cost and schedule contingency. Detailed review and approval of proposed changes.
Increasing construction cost escalation rates (cost)	Maintain adequate contingency escalation to mid-point of construction. The project is also currently carrying a 20% contingency at the low range and 25% at the high range. Continue to monitor local construction market trends as the project progresses to CD-2. CM/GC will provide pre-construction estimating services.
Significant Increase in project scope related to technical/design issues (Cost and Schedule)	Maintain adequate cost and schedule contingency. Robust engineering and design reviews.
Continuing resolution(s) and delay in FY17/18 Funding (schedule)	FY17/18 funding is critical for the completion of the construction on the planned schedule. Project has planned for a 12-month CR in FY17 and a 3-month FY18 CR. Will continue to monitor closely with the program.
Limited competition and subcontractor availability (cost and schedule)	CM/GC to provide outreach to stimulate project recognition in the subcontractor community. CM/GC is the preferred procurement methodology to obtain adequate subcontractor participation in the bid process and facilitate early recognition of labor availability issues.

CFR – Transition to Operations

- Occupant/Equipment relocation costs are “off-project”
- A Transitions to Operations plan will be developed prior to CD-2
  - Initial Considerations
    - Data migration requirements – Data vs. compute
    - Equipment refresh schedules
    - Data back-up requirements
- Beneficial Occupancy Readiness Evaluation (BORE) procedures are in place and detailed in BNL SBMS
- A successful BORE review = Substantial Completion

CFR – Schedule

- CFR Preliminary Schedule Assumptions
  - Plan for 1 yr. FY17 and 3 mos. FY18 Continuing Resolution
  - 18 mos. Construction & Commissioning
  - 12 mos. Schedule Contingency
  - Balance of PED + Construction Funds Received FY18
  - Site Prep. 5 mos. (Incl. schedule contingency)
  - Move-in is “Off-project Cost”

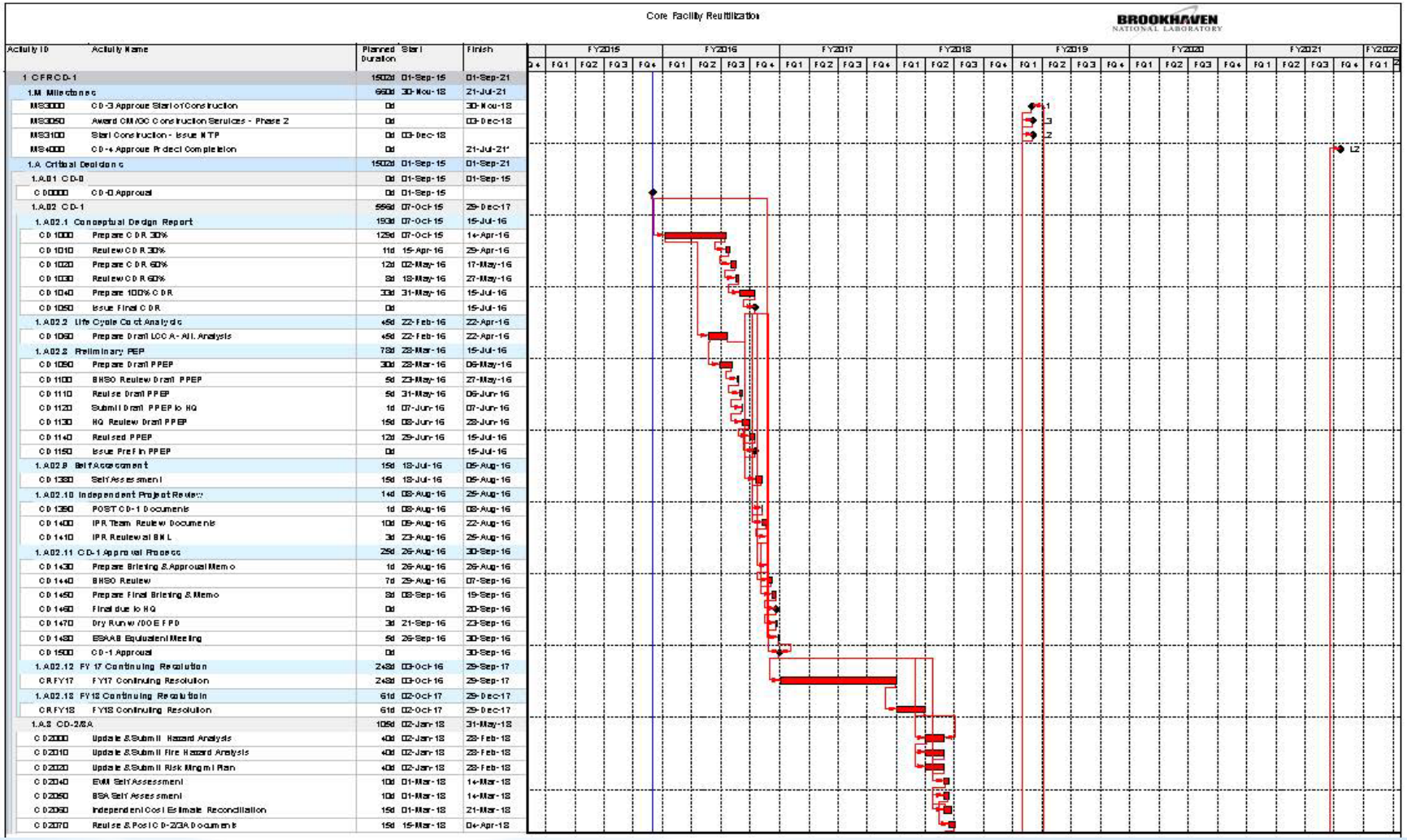


CFR – Schedule

- Preliminary Schedules are available for review:
  - Milestone Schedule
  - Summary Schedule
  - Critical Path
  - Detailed Schedule
  - Resource-Loaded Schedule
  - Acumen Fuse reports generated based on Preliminary Schedule

CFR – Schedule

- Preliminary Critical Path Schedule



CFR – Lessons Learned

The CFR team has the benefit of Lessons Learned from multiple years of SLI project experience…

- Renovation projects – ***expect the unexpected!***
- Potential benefits of the CM/GC procurement methodology vs. traditional Design/Bid/Build
  - Key to success is the value of pre-construction services!
  - Develop a good CM/GC contract & SOW
- Strive to maintain appropriate add and ***deduct*** scope contingency - ***throughout the life of the project***

CFR – Project Manager's Concerns

- **Change**
  - Programmatic – Evolution of program requirements
  - Technology – Roll out of new technologies
- **CFR Construction Safety**
  - Unfamiliar Workforce
  - Working at Heights

1. **Maintain a questioning attitude**
2. **Diligence**
3. **Familiarity breeds complacency!**

Questions?

Back-up Slides

Data Center Optimization Initiative (DCOI)

Requirements and Compliance Discussion

Policy: DCOI requires agencies to develop & report on data center strategies to:

- Consolidate inefficient infrastructure
- Optimize existing facilities
- Improve security posture
- Achieve cost savings
- Transition to more efficient infrastructure such as cloud and inter-agency shared services

Leadership and Responsibilities: Agency CIO is responsible for implementing and measuring progress towards meeting these *GOALS / OPTIMIZATION TARGETS*

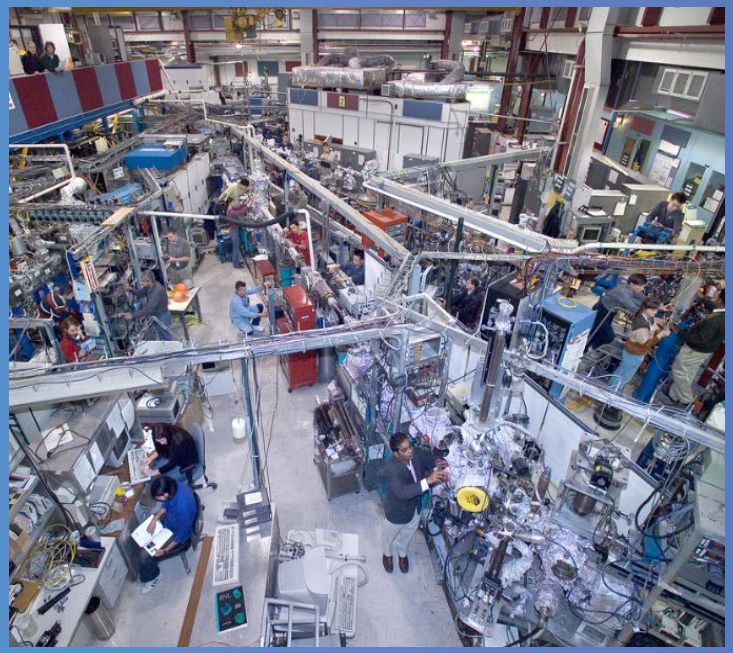
Transition to Cloud and Data Center Shared Services	Development freeze for New and Current data centers ○ Beginning 180 days after 8/1/16 agencies may not budget funds or resources towards initiating a NEW data center or significantly expanding an existing data center without approval from OMB OFCIO IMPACT TO CFR Project: None Agencies to: • Submit written justification to DOE CIO. • consider cloud infrastructure *where possible* • take into account cost, program requirements and application needs

	CFR Pathway to compliance: • The BNL CFR Project team's view is that this requirement has already been met. DOE submitted the OMB Exhibit 300 and other CFR description documents as part of the DOE FY 17 agency budget request. The documents were reviewed by OMB and subsequently incorporated in to the President's FY 17 budget request submitted to Congress in January 2016. • CFR Project has completed an Analysis of Alternatives which includes an alternative to use cloud based services and performing computing at other facilities.
Consolidation and Closure of Existing Data Centers	Agencies shall evaluate options for the consolidation and closure of existing data centers. IMPACT TO CFR Project: None CFR Project supports this initiative by: • The New CFR Facility will allow for the RACF to vacate existing, antiquated, non-compliant data center facilities and re-populate new, optimized, energy efficient facilities that provide a path to compliance with DCOI requirements while continuing to meet their scientific mission need. • The new CFR data center will allow for additional opportunities for consolidation of computing resources via BNL's Computational Sciences Initiative (CSI). CSI HPC institutional computing resources reside within and is managed by the RACF providing access to data analysis resources to the grater BNL research community While a small computing footprint (network services) will remain, the existing B515 RACF will ultimately be vacated. The facility is to be re-purposed for utilization as a conventional (non-data center) facility.
Cloud Investment	See Transition to Cloud and Data Center Shared Services above
Shared Services Managing Partner	Requirement for GSA to establish and maintain a data center shared services marketplace and coordinate shared services for interagency consumption. IMPACT TO CFR Project: None

Classification of Physical Data Centers	Agencies shall categorize data centers as either tiered or non-tiered data centers IMPACT TO CFR Project: None • The Proposed CFR Facility meets the definition of a "Tiered" Data Center as it is a separate physical space, employs UPS technology, contains a dedicated cooling system, and incorporates a generator for prolonged power outages
Energy Metering and Energy Efficiency	Agencies shall install automated energy metering tools and shall use these to collect and report energy usage data in their data centers to OMB. IMPACT TO CFR Project: None • CFR project provides pathway to compliance by: ○ employing a Data Center Energy Practitioner (DCEP) to manage energy performance ○ Implement energy metering capable of measuring PUE ○ Design and operate the CFR facility to maintain a PUE no greater than 1.4 and strive to design and operate the facility to achieve a PUE no greater than 1.2
Automated Infrastructure Management	Agencies shall replace manual collections and reporting of systems, software and hardware inventory housed within data centers with automated monitoring inventory and management tools. IMPACT TO CFR Project: None • CFR project provides pathway to compliance by: ○ The CFR project shall install automated monitoring, inventory, and management tools (e.g. Data Center Infrastructure Management (DCIM) software). ○ These tools shall provide the capability to measure progress towards metering, PUE, utilization and, virtualization metrics identified as Optimization targets as defined in the DCOI memorandum.

Core Facility Revitalization (CFR)

Critical Decision -1 (CD-1) Independent Project Review



Hazard Removal Project
Building 725

August 23rd – 25th, 2016

Robert Selvey, CIH
Safety & Health Services Division

BROOKHAVEN NATIONAL LABORATORY
a passion for discovery

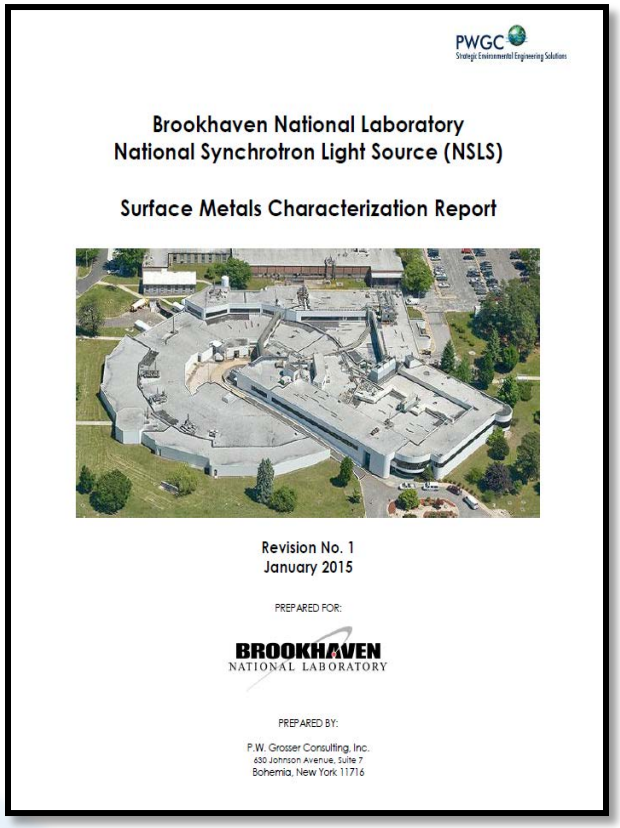
U.S. DEPARTMENT OF ENERGY | Office of Science

B725 Hazard Removal Project (HRP)

Topics

- Scope of Hazard Removal Project (HRP)
- Cleanup Status / End State
- Details on Lead Removal, Sampling Effort, & Path Forward
- Conclusions

B725 Hazard Removal Project (HRP)


PWGC
Strategic Environmental Engineering Solutions

Brookhaven National Laboratory
National Synchrotron Light Source (NSLS)

Surface Metals Characterization Report

Revision No. 1
January 2015

PREPARED FOR:

BROOKHAVEN
NATIONAL LABORATORY

PREPARED BY:

P.W. Grosser Consulting, Inc.
630 Johnson Avenue, Suite 7
Bohemia, New York 11716

Hazard Characterization

- Removal Project Scope based on Surface Metals Characterization Report- **January 2015**
- Additional Hazards found during HRP execution
  - Including: Asbestos, Copper Beryllium Components, & Beryllium on surfaces
- **$7.4M Hazard Removal Project Completed 3/31/16**
- End-state Conditions well documented in 4/9/16 Closeout Report

B725 Hazard Removal Project (HRP)

Scope of Hazard Removal Project

*…to **safely** and efficiently remove hazards and hazardous conditions resulting from NSLS operations to prepare it for the post-operations phase of the facility life cycle.*

Employee safety & exposure during Clean-out

- Perfect Safety record
- Personnel airborne exposure samples (Be and Pb breathing zone of worker) were taken on a weekly basis to verify effectiveness of controls & to ensure compliance with DOE, ACGIH and OSHA exposure limits.
  - No Time Weighted Average over-exposures to DOE/ACGIH/OSHA exposure limits for airborne metals were recorded throughout the project
- Ergonomics controls were used to prevent musculoskeletal injury during lead shielding movements

B725 Hazard Removal Project (HRP)

Hazards identified and handled during project execution

- Asbestos
- Beryllium and alloys
- Cadmium
- Lead dust on surfaces and Bulk lead
- Biohazards
- Chemicals, experimental samples, indium, gallium
- Compressed gases
- Flammables/combustibles
- Radiological sources
- Sources of electrical/mechanical energy
- Confined spaces

Asbestos

- Facility survey performed by outside contractor for MPO. ACM in:
  - Lobby ceiling tile
    - To be removed by F&O (outside scope of CFR project).
  - Roof Flashing
    - To be addressed by CFR project scope.
  - 1st Floor: 6 Laboratory hoods (ACM transite interior)
    - Labelled (no impact to CFR Project)
  - Booster/Linac Ceiling – samples free of ACM
  - Infrastructure insulation – samples free of ACM
  - Drywall & spackling- free of ACM
  - Gypsum board, laboratory countertops, hoods, pipe insulation, etc., evaluated by BNL Steam Shop- free of ACM
  - No friable fireproofing /acoustic spray-on material was used.

Other Health Hazards

- Beryllium components
  - Beryllium windows removed/disposed
  - Copper-beryllium components removed/disposed
  - Post-removal work areas surveyed and cleared

- Biohazards
  - Biological specimens removed/disposed

- Chemicals, experimental samples, etc.
  - Removed/disposed
  - HRP chemicals used/transferred
  - Compressed gases - Removed/disposed

Beryllium Window

Other Health Hazards

- Magnetic fields
  - Hundreds of ion pumps & Insertion devices removed/disposed
- Nanomaterials
  - No history of unbound nanomaterials in the NSLS
  - Suspect ductwork removed
- Experimental equipment containing residual oil/Freon
  - Pumps moved/disposed
  - A/C or refrigeration units evacuated or removed/disposed
- Laboratory hoods/sinks
  - No mercury, No rad
- Exhaust Hoods sampled
  - No perchlorates

Radiological Hazards

Potential radioactive Accelerator components (e.g., magnets, beam pipes, insertion devices) in:

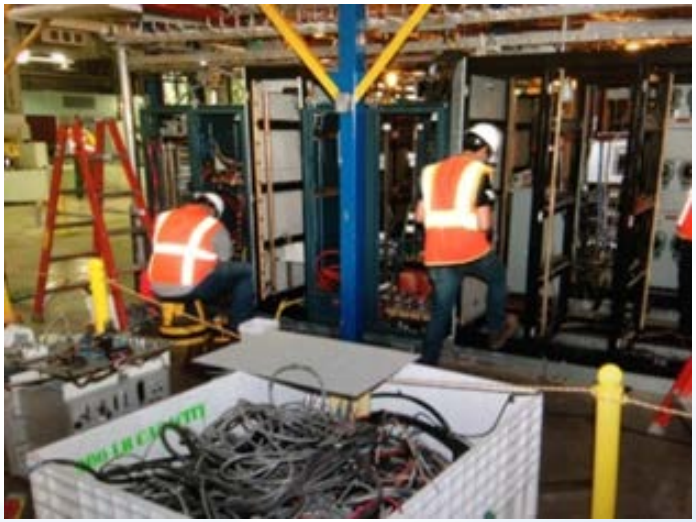
- Linac
- Booster
- Transport lines
- VUV ring
- X-Ray ring
- DU shutters
- Radiological sources

Radiological hazards/waste**:** Magnets, vacuum chambers, accelerator components, insertion devices removed/disposed

- RMCAs rad surveys performed
- **NSLS free of radioactive material**
- **No historical or present day evidence of loose contamination**

Research Systems Removed

- Accelerators and associated support systems
- Beamlines and associated equipment
- Electrical/mechanical systems removed essentially back to points of interface with Building 725 infrastructure
- All Interface points left in inherently safe configuration (air gapped, capped, blanked, etc.)
- Single line diagrams & panel schedules updated



Lead

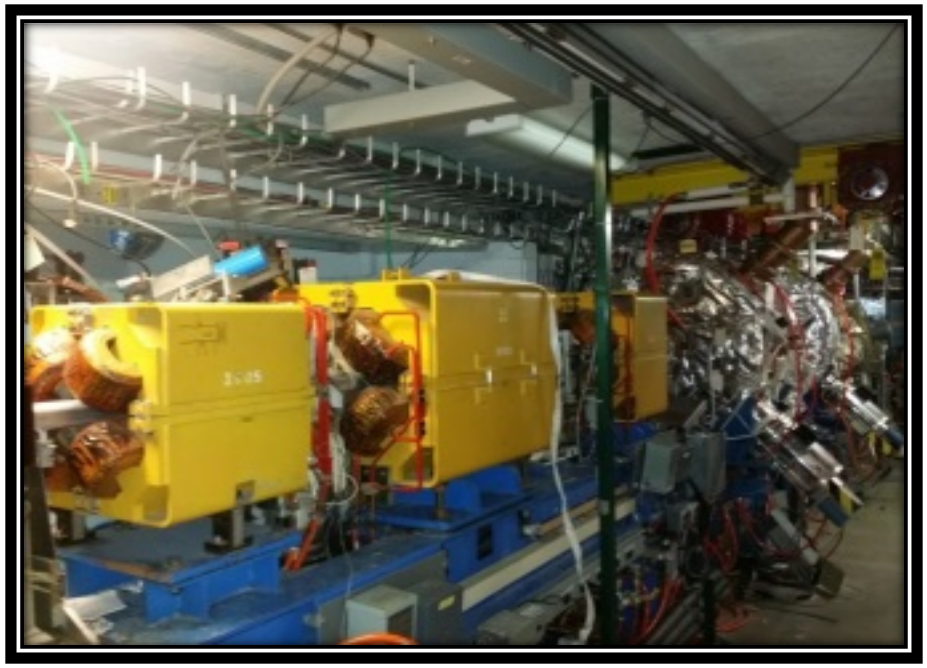
Lead Shielding Block

- Lead shielding removal
  - Over 500,000 pounds (> 99.9%) removed/disposed/recycled
  - Remaining shielding
    - Steel encapsulated lead in X-17 hutch, nonhazardous in current state
    - HVAC penetrations into the X-Ray tunnel
- Residual lead dust on surfaces remains

BNL Internal Standard for lead on surfaces

- **Housekeeping** (Operational)**: 250 ug/ft^2** (26.9 ug/100 cm^2)
- **Equipment Release** and **Public Areas**: **40 ug/ft^2** (4.3 ug/100 cm^2)

X-Ray Ring



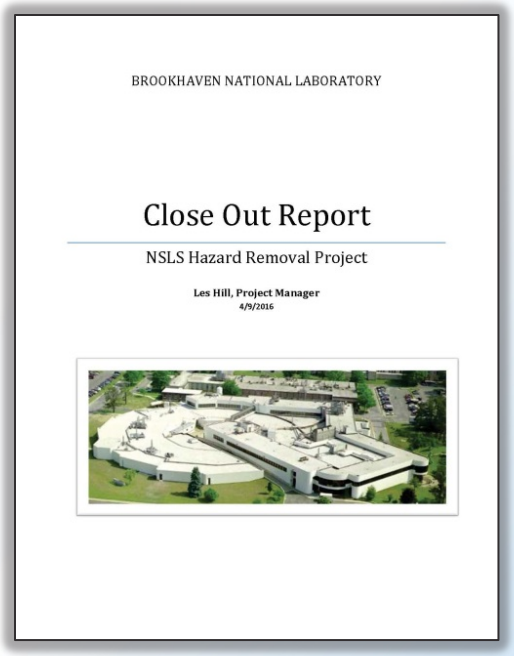
Booster

X-Ray Experimental Floor

Electrical Commodities

4/9/2016 Closeout Report

- All Building 725 **HVAC systems** have some internal contamination …noted during facility characterization
  - Quantifiable levels of lead found during characterization with 1,000 µg/ft^2 max
  - 18 supplemental wipe samples taken 4/2016, all exceed public criteria, with 4,274 µg/ft^2 max


BROOKHAVEN NATIONAL LABORATORY

Close Out Report

NSLS Hazard Removal Project

Les Hill, Project Manager
4/9/2016

- Exposed horizontal surfaces throughout 1st Floor
  - 200 supplemental wipe sample campaign during November 2015
  - Overhead & wall samples generally below the housekeeping standard
  - Depositional areas (tops of structural shapes and ledges, top surfaces of electrical and mechanical equipment, etc.) typically in 300-800 µg/ft^2 range with some locations > 4,000 µg/ft^2

- Full data set available via Closeout Report

Residual Lead Hazards to be Remediated

Location	Housekeeping Release	General Public release
1st Floor- ground surfaces (floors)	X	X
Horizontal surfaces (tops of structural members, ledges, top surfaces of electrical and mechanical equipment, etc.)	X	X
Overhead & walls	✓	✓
Lobby and 1st floor non-industrial/scientific area	✓	✓
Internal surfaces of HVAC	✓	X
X-17 Hutch, nonhazardous in current state		

CFR Project Scope: Site Preparation Phase under the CFR Project

- All 1st Floor residual lead on surfaces to be removed and/or encapsulated
- HVAC Ductwork to be removed and/or cleaned
- Bulk lead to be removed

Residual Lead Removal Path Forward

- CFR Project has a comprehensive plan for mitigating remaining lead dust - *Lead Dust Removal Plan prepared by JC Broderick - August 2016*

- **CFR Project Scope**
  - **Site Preparation activities**
    - 1st Floor Ductwork to be removed/cleaned
    - 1st Floor VCT to be removed. Concrete to be cleaned/encapsulated
    - 1st Floor Residual Lead Dust to be addressed

- **Off Project Scope**
  - 2nd Floor renovation
    - HVAC Ductwork - 65% cleaned. Remaining Ductwork scheduled for cleaning
    - Residual Dust cleaning as part of 2nd floor renovation
  - Lobby area asbestos ceiling tile scheduled for removal as part of 2nd floor renovation

Questions?

Backup slides

End State of hazard removal

- Linac, Booster, VUV Ring and X-Ray Ring accelerators removed
- Lead shielding removed with the limited exception of localized HVAC penetrations into the X-Ray Ring tunnel
- Beamlines and experimental hutches removed with the exception of X-17
- Research mechanical systems removed essentially back to the Building 725 MERs; open ends of piping systems capped
- Electrical systems, equipment, instrumentation and associated commodities (e.g. cable trays, conduits, etc.) removed; electrical systems air gapped at facility interface points
- RMCAs surveyed and de-posted; Building 725 is free of radioactive material
- Building 725 free of non-radioactive hazardous materials and equipment that were formerly part of research infrastructure
- Building 725 free of chemicals, materials, equipment and debris associated with previous research operations
- Residual Lead on surfaces

Residual Lead Contamination in NSLS Ductwork

- All Building 725 **HVAC systems** have some internal contamination …noted during facility characterization
  - Quantifiable levels of lead found during characterization with 1,000 µg/ft^2 max
  - 18 supplemental wipe samples taken 4/2016, all exceed public criteria, 4,274 µg/ft^2 max

1st Floor Ductwork

To be removed as part of the Site Prep Phase under the CFR Project.

2nd Floor Ductwork

Portion of the second floor ductwork cleaning completed 7/2016. Remaining ductwork on the 2nd to be cleaned by F&O (outside of CFR Project)

Lead Testing and Cleanup Standards

SHSD Procedure IH75190 *Surface Wipe Sampling for Metals,* provides BNL with*:*

- Uniform procedure for representative sampling
- DOE requirements for Beryllium surface levels

  (Housekeeping: 3 ug/100cm^2; Equipment Release & 0.2 ug/100cm^2)
- BNL internal recommended standards for other metal's safe surface levels (adopted by many, including NIOSH, ANSI/ASTM, OSHA Letter of Interpretation)

BNL Internal Standard for lead on surfaces

- **Housekeeping** (Operational)**: 250 ug/ft^2** (26.9 ug/100 cm^2)
- **Equipment Release** and **Public Areas**: **40 ug/ft^2** (4.3 ug/100 cm^2)

Notes: ug/ft^2 – micrograms of metal per square foot of surface (EPA/HUD)
ug/100 cm^2 – micrograms of metal per 100 square centimeters of surface (DOE Beryllium)

Attachment 9.3

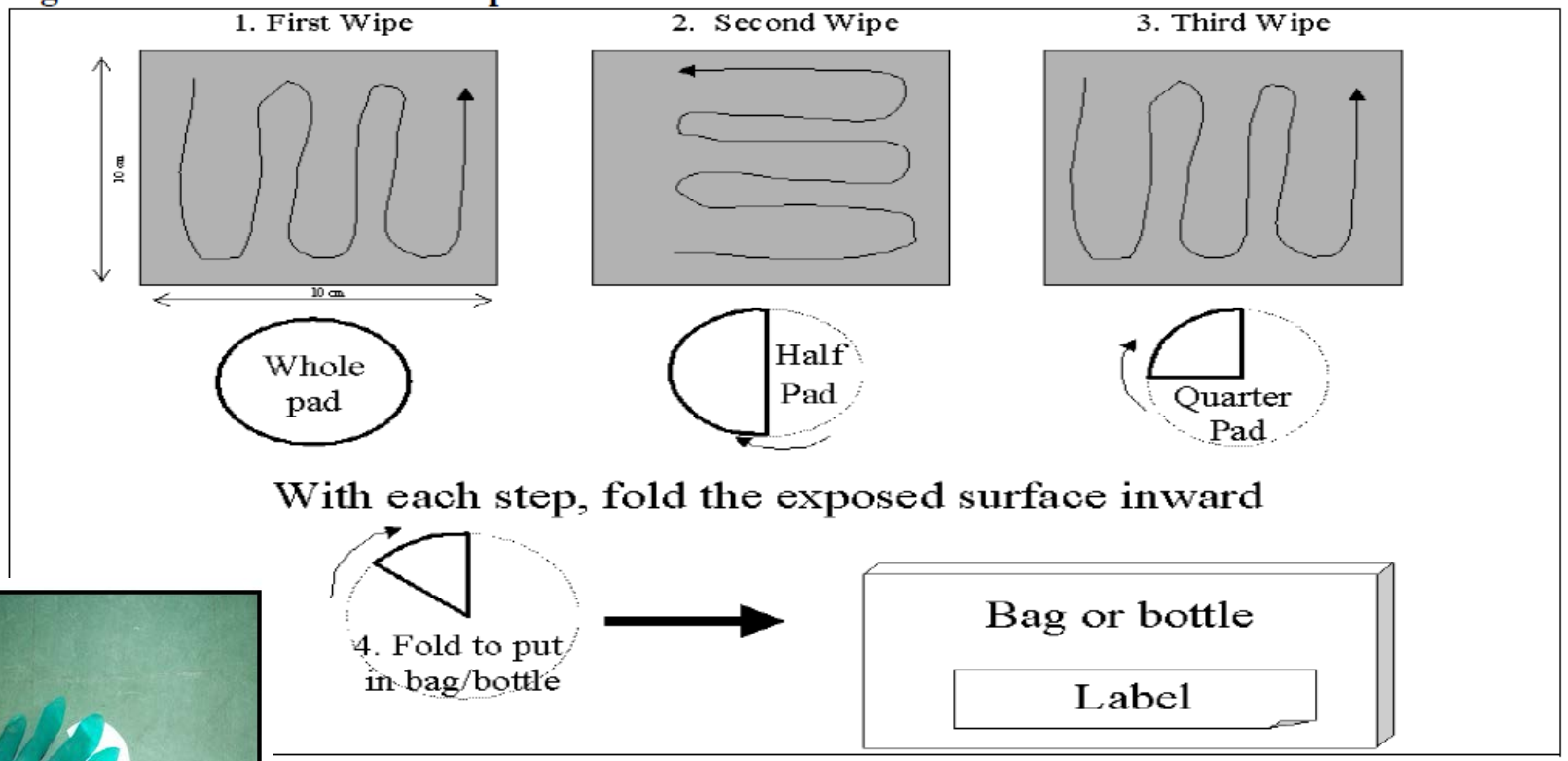
Surface Wipe Criteria Requirements & Recommendations

Compound	Criteria ug/100cm^2	Criteria type	M/R	Basis for Calculation	Lower of	
					OSHA PEL ug/m^3	ACGIH TLV 2005 ug/m^3
Arsenic (As)	10	Operational- Housekeeping	R3	OSHA Technical Manual	10 [skin irr, sensitize, dermatitis]	10 [Skin cancer]
	0.67	Equipment Release & Public areas				
Beryllium (Be)	3	Operational- Housekeeping	M	DOE 10CFR850.30	2	2
	3	Equipment Release to DOE operational areas	M	DOE 10CFR850.30		
	0.2	Equipment Release & Public areas	M	DOE 10CFR850.31		
Cadmium (Cd)	20	Operational- Housekeeping	R2	OSHA Technical Manual	5 [1910.1027] 200 [Z.2]	2 [R] 10 TD]
	1.3	Equipment Release & Public areas				
Chromium (Cr) +3	500	Operational- Housekeeping	R3	OSHA Technical Manual	500	500 [dermatitis]
	33	Equipment Release & Public areas				
Chromium (Cr) +6	0.5	Operational- Housekeeping	R3	OSHA Technical Manual	5 [Skin sensitize]	10
	0.03	Equipment Release & Public areas				
Lead (Pb)	26.9	Operational- Housekeeping	R1	EPA TSCA & HUD	50	50
	4.3	Equipment Release & Public areas	R1	EPA TSCA & HUD		
Nickel (Ni)	1000	Operational- Housekeeping	R3	OSHA Technical Manual	1000 [dermatitis]	1500 [dermatitis]
	67	Equipment Release & Public areas				

Notes:
ACGIH TLV 2005 as cited in DOE 10CFR851

6.2. **Wipe Technique:** BNL SHSD IH Group has selected the NIOSH method of collecting wipe samples. For uniformity, this method should be used for all sampling surface to be sampled (Visually depicted in Figure A)

Figure A: NIOSH Surface Wipe Method



Building 725 Hutch X-17

- Lead is in walls of the hutch, sandwiched between non-lead material

HVAC penetrations into the X-Ray Ring Tunnel

Lead between concrete and aluminum plate in former HVAC plenum penetrations through floor/wall

Penetration in wall

Core Facility Revitalization (CFR)

Critical Decision -1 (CD-1) Independent Project Review

ESS&H Overview

Ray Costa, Manager

F&O / Operational Excellence

August 23rd – 25th, 2016

BROOKHAVEN NATIONAL LABORATORY

a passion for discovery

U.S. DEPARTMENT OF ENERGY | Office of Science

Outline

- ESS&H Vision Statement for the CFR Project
- Project ESS&H Team
- ESS&H Reviews
- Hazard Analysis Summary
- Construction Safety Program Implementation of ISM
- Summary

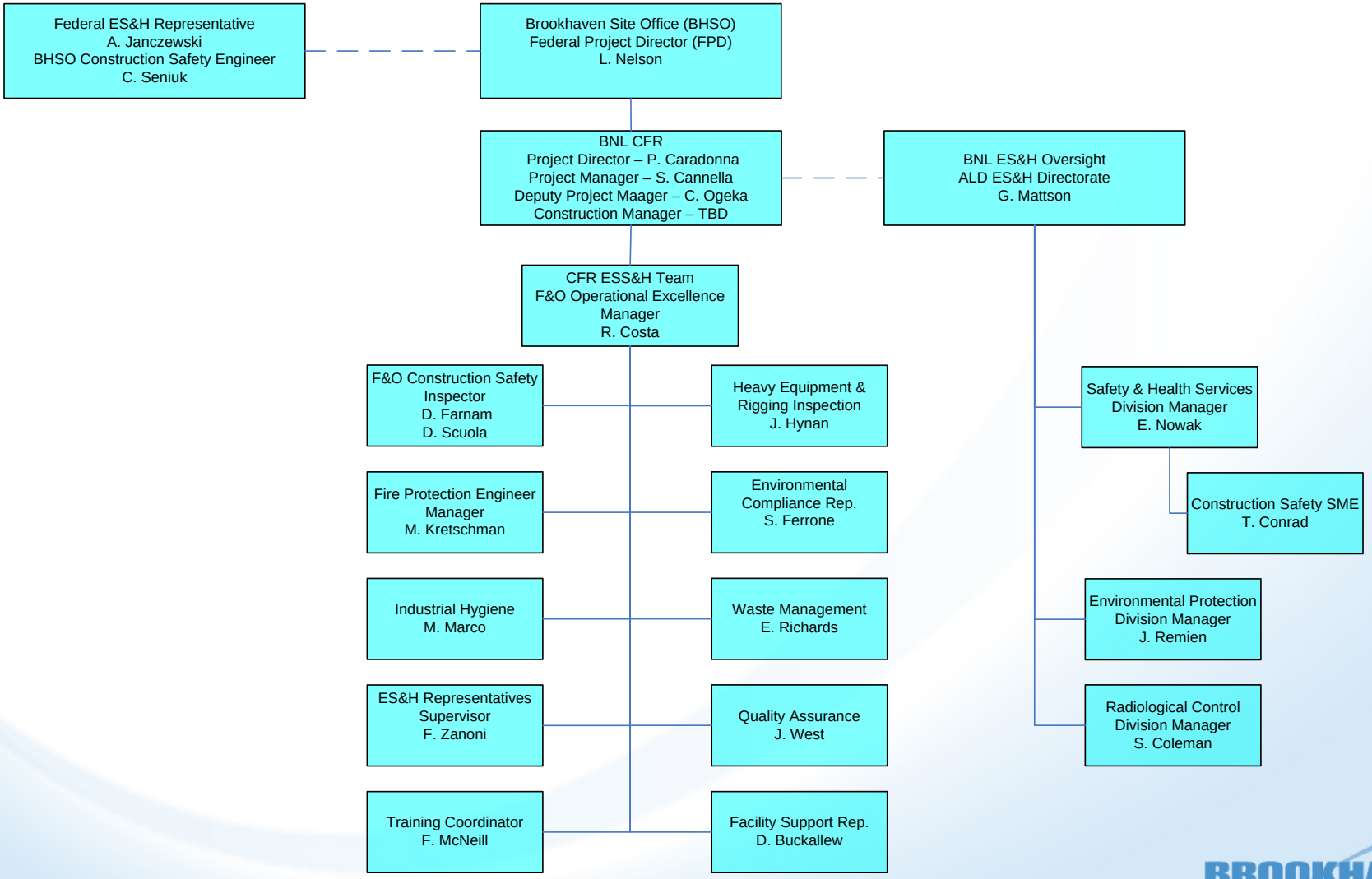
Core Facility Revitalization - CFR ESS&H Vision

To complete the CFR in a safe, environmentally respectful, cost efficient manner that meets our stakeholder's needs

- Maintain a safe workplace for our workers, contractors, subcontractors, site occupants and guests
- Protect human health within our project boundary
- Achieve and maintain compliance with all applicable ESSH requirements

CFR ESS&H Team

Core Facility Revitalization (CFR)
ESS&H Organization

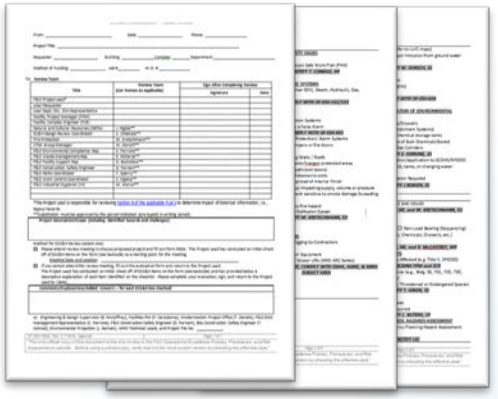


ESS&H Reviews

ESS&H Review process starts at project conception and continues throughout the life of the project incorporating lessons learned along the way

- Design
- Site preparation
- Relocation and/or modifications of existing utilities
- Construction
- Disposal and/or recycling of construction materials and wastes
- Selection, installation and testing of components, systems and equipment

ESS&H Reviews (Cont.)



Conceptual Design Phase ESS&H

- F&O Project ESS&H (500A) Review Process
  - Recognized by DOE as a best practice
  - Identifies environmental, hazard and safety issues
    - to design out or take mitigative actions for as many of the concerns as possible during the design phase
    - Address the remainder during construction
    - Review Team Includes:

F&O Project Lead	Facility Project Manager	Waste Management
Facility Complex Engineer	Facility Support Rep.	NEPA Coordinator
Environmental Compliance	User Representatives	Fire Protection Engineer
F&O Construction Safety Engineer	ES&H Design Review Coordinator	DOE Brookhaven Site Office
		F&O Construction Work Control Coordinator

ESS&H Reviews (Cont.)

- A 500A review for the CFR will be conducted at the start of conceptual design
- The preliminary hazard analysis developed by:
  - Reviewing the NSLS Hazard Removal Project Closeout Report
  - Reviewing 500As for multiple projects within the building developed during the remediation projects
  - The Project Team performed additional sampling within the facility
  - Facility Complex Manager, Facility Complex Engineer, Research Space Manager, and Facility Project Manager were heavily involved in the early scoping exercises and validation/assessment of existing conditions
  - Preliminary Hazard Analysis Report prepared
  - Preliminary Fire Hazard Analysis performed
- BNL has experience in dealing with the hazards identified

Bldg. 725
Hazard Removal Project (HRP)

Hazards identified and removed during HRP project

- Asbestos
- Beryllium and alloys
- Cadmium
- Residual lead dust on surfaces and bulk lead
- Biohazards
- Chemicals, experimental samples, indium gallium
- Compressed gases
- Flammables/combustibles
- Radiological sources
- Sources of electrical/mechanical energy
- Confined spaces

Bldg. 725 – Remaining CFR Hazard Analysis Summary: Materials

Hazardous Material	Source or Location	Comments
Asbestos	• Roof flashing • Other o Mastic materials o Wire insulation o Window and door caulking / putty o Fire proofing	• Flashings will be addressed by CFR roof replacement scope of work. • Though not identified, sampling will take place as needed and abatement performed by F&O or an specialty contractor as appropriate.

Bldg. 725 – Remaining CFR Hazard Analysis Summary: Materials

Hazardous Material	Source or Location	Comments
Lead, lead dust, & residual toxic metals*	• Majority of the first floor's ground surfaces are above the BNL housekeeping standard	• All first floor residual lead on surfaces to be removed and/or encapsulated.
	• Horizontal surfaces (tops of structural members, ledges, top surfaces of electrical and mechanical equipment, etc.)	• Horizontal surfaces typically above the BNL housekeeping standard and will be cleaned and/or encapsulated
	• Overhead & walls	• Overhead & walls are generally less than BNL housekeeping standard & general public standard
	• Lobby and first floor nonindustrial/scientific areas	• Lobby and first floor non-industrial/scientific areas are below the BNL housekeeping standard & general public standard.
	• X-17 Hutch	• The X-17 hutch contains steel encased lead that does not pose a risk or facility hazard but will be removed
	• Internal surfaces of HVAC	• HVAC ductwork internal surfaced have been found to be above BNL general public standard and some above BNL housekeeping standard, these will be removed and/or cleaned.

* Sampling to be conducted for residual toxic materials and abatement performed as needed to BNL procedures

Bldg. 725 – Remaining CFR Hazard Analysis Summary: Materials

Hazardous Material	Source or Location	Comments
Lead paint	• On all building painted components, materials, and equipment.	• Sampling shall be completed by the F&O Industrial Hygiene (IH) Representative.
PCBs	• Transformer/capacitor oil • Light ballasts • PCB containing paint	• Prior to demolition activities, each of these potential PCB sources are to be verified as absent at each work location. PCBs will be abated and disposed of by BNL prior to demolition.
Mercury	• Mercury relay switches • Fluorescent bulbs • Wall thermostats • Sink traps & sanitary lines	• Sampling will be performed prior to demolition/construction; however some monitoring or sampling may not be feasible until demolition/construction proceeds. • All sink traps shall be removed by BNL prior to demolition; if mercury is found to be present, disposal will be by BNL. IH will be present during demolition stage to monitor.

Bldg. 725 – Remaining CFR Hazard Analysis Summary: Radiological

- There is no radioactive material remaining in Building 725 and the facility has been de-posted.

Bldg. 725 CFR
Hazard Analysis Summary: Job

- Typical job hazards
  - Building Access – occupants and pedestrians
  - Project site access – project personnel
  - Electrical energy
  - Use of hand tools
  - Use of ladders
  - Working 6 feet or higher above the floor
  - Equipment operations
  - Material handling
  - Working with electricity
  - Demolition debris and construction material removal and movement
  - Etc.

Construction Safety Program

ISM forms the framework of the construction safety program

- Mandated contractually to the prime and all sub-tier contractors through BNL Standard Based Management System (SBMS) & F&O Procedures

Core Function (CF) 1: Define Work

Guiding Principle (GP) 5: Identify ES&H Standards and Requirements

- Preliminary construction hazards identified by:
  - Reviewing HRP Project close out report
  - using the 500A ESS&H review process
  - material sampling within the facility
  - involve Facility Complex Manager, Facility Complex Engineer, Research Space Manager, and Facility Project Manager
  - Lessons Learned
- ES&H standards and requirements identified and incorporated into contractual documents
- Contractors must qualify on safety as part of bid package (past poor safety performance is a disqualifier)

Construction Safety Program (cont.)

CF 2 & 3: Identify Hazards and Establish Controls

GP 6: Hazard Controls Tailored to Work

- F&O Construction Work Permit
  - Prepared by F&O and the contractor with SME's
  - Identifies hazards & concerns associated with
    - Work to be performed
    - Environment protection
    - Safety and Security
  - Identifies controls
    - Eliminate the hazard or concern
    - Engineered controls
    - Administrative & procedural controls
    - PPE
  - Establishes work plan
  - Requires a pre-job briefing with workers
  - Supervisors and workers sign the permit

Construction Safety Program (cont.)

CF 2 & 3: Identify Hazards and Establish Controls (cont.)

GP 1: Line Manager clearly responsible for ES&H

GP 2: Clear ES&H roles and responsibilities

- Contractor required to develop Health & Safety Plans (HASP)
  - HASP must contain job specific phase-hazard analysis (PHA) / Safe Work Plan (SWP) acceptable to BNL
  - All Subs must comply with prime's HASP plan
  - Reviewed for acceptance by BNL Safety Engineering prior to authority to start work
- HASP serves as contractor's safety basis for performing work
  - Demonstrates compliance and knowledge with:
    - 10CFR851
    - OSHA
    - ISM CF & GP
    - BNL and F&O contract safety requirements

Construction Safety Program (cont.)

CF 4: Perform work to approved plan

GP 3: Competence commensurate with responsibilities

GP 4: Balance priorities

- Implementating
  - HASP,
  - PHA/SWP,
  - Special Permits
    - e.g., digging, cutting/welding, and power outages,
- Contractor must assign a dedicated safety representative and alternate acceptable to BNL
  - Construction safety management experience and specialized training appropriate to the project (e.g., asbestos, electrical safety, etc.)
  - OSHA 30 hours trained for multi-trades
  - Must be on site at all times when work is being performed

Construction Safety Program (cont.)

Core Function 4: Perform Work to Approved plan (cont.)

- All contractor workers must go through BNL Contractor/Vendor Orientation (CVO) prior to reporting to the work site
  - Required for all contractors and their subcontractors
  - Instructs Contractor personnel on appropriate response to all emergencies at BNL
  - Reviews their rites and responsibilities under 10CFR851
  - Reinforces BNL's strong construction safety culture
  - Reinforces that all injuries are to be reported to BNL project/safety personnel
    - Conduct thorough and timely accident investigation
    - Implement corrective and preventative measures
    - BNL reserves the right to monitor contractor investigtation or perform its own

Construction Safety Program (cont.)

Core Function 5: Provide Feedback

- Weekly meetings with contractor
- Daily Construction Safety Inspections
  - Conducted by F&O Construction Safety Engineer (CSE)
  - Oversight provided by BNL Construction Safety Engineering
  - Inspection Checklist used to record results
  - OSHA and BNL standards
- Negative observations are brought to the immediate attention of the contractor's safety representative, Project Manager, and BNL Field Supervisor
  - Follow-up conducted to ensure observations are corrected
  - Trending performed and used to strengthen the Contractor and BNL Safety Program

Summary

- We have an experienced professional ESS&H Project team in place
- A well established and tested in-place Construction Safety Program
  - ISB, RSL-I, RSL-II, NSLS-II, etc.
  - Excellent ES&H safety record for recent projects

- Preliminary ESS&H Reviews have been conducted, comments evaluated and incorporated as appropriate into planning and development of a Preliminary Hazard Analysis
  - 500A process recognized by DOE as a best practice

- ESS&H Reviews will continue throughout the project and controls will be established and implemented to eliminate or mitigate hazards

Additional Information

ES&H Review

ES&H 500A Review Team

- RSL II Project Lead
- ES&H Project Review Coordinator
- Facility Support Representatives
- User Dept. ES&H Coordinators
- Waste Management Representative
- F&O Operations & Maintenance Supervisor
- Fire Protection Engineer
- Building Managers
- Safety Professionals
- User Representatives
- Environmental Compliance Representatives

ES&H Review

F&O ES&H 500A Hazards and Issues Reviewed (partial List)

- Industrial Safety
  - Electrical
  - Equipment
  - Excavation & penetrations
  - Working at heights
  - Fire protection
  - Material Handling
- Environmental
  - NEPA
  - Radioactive Emissions
  - Pill Prevention
  - PCBs
  - Environmental system impacts
- Radiation
- Waste Management
- Industrial Hygiene
  - Confined Spaces
  - Ergonomics
  - Indoor Air Quality
  - Asbestos
  - Lead and other metals
  - Mercury
  - Fumes/Mist/Dust Generation
  - Chemicals/Solvents
  - Noise
- Facility
  - Structure/Systems impact
  - Facility use
  - Environmental permits
  - Security

ES&H Review

Hazards Identified and Evaluated

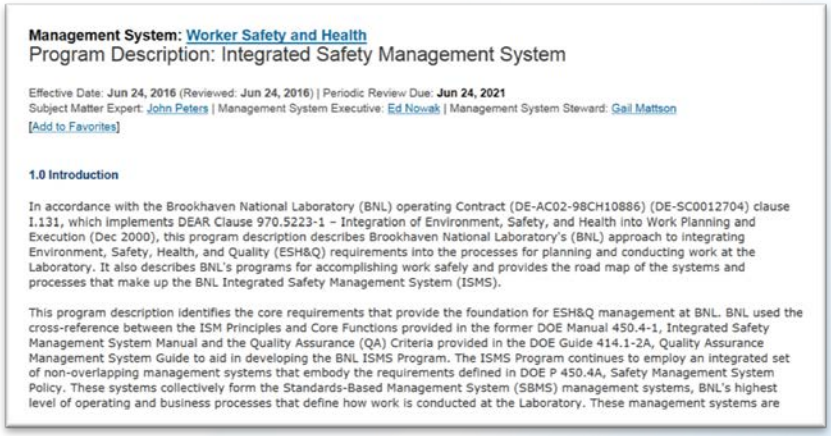
- Asbestos
- Lead based paint
- Hazardous metals surface contamination
  - Lead
  - Beryllium
  - Cadmium and other heavy metals
- Mercury
- Perchlorates (explosive hazards)
- Radiological contamination
- Polychlorinated biphenyl (PCB)

Construction Hazards Being Addressed by Work Planning

- Building occupant safety
- Construction personnel safety
- Noise
- Silica & Dusts (Crushing Concrete)
- Fire
- Asbestos abatement
- Fumes, Mists & dusts
- Heavy equipment operation
- Welding & torch cutting
- Coatings application
- Slips, trips & falls
- Access and egress

Integrated Safety Management System (ISMS)

- BNL's Standard Based Management System (SBMS) describes BNL's approach to integrating ESH&Q requirements into process for planning and conducting work at the Laboratory



Management System: Worker Safety and Health
Program Description: Integrated Safety Management System

Effective Date: **Jun 24, 2016** (Reviewed: **Jun 24, 2016**) | Periodic Review Due: **Jun 24, 2021**
Subject Matter Expert: John Peters | Management System Executive: Ed Nowak | Management System Steward: Gail Mattson
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1.0 Introduction

In accordance with the Brookhaven National Laboratory (BNL) operating Contract (DE-AC02-98CH10886) (DE-SC0012704) clause I.131, which implements DEAR Clause 970.5223-1 – Integration of Environment, Safety, and Health into Work Planning and Execution (Dec 2000), this program description describes Brookhaven National Laboratory's (BNL) approach to integrating Environment, Safety, Health, and Quality (ESH&Q) requirements into the processes for planning and conducting work at the Laboratory. It also describes BNL's programs for accomplishing work safely and provides the road map of the systems and processes that make up the BNL Integrated Safety Management System (ISMS).

This program description identifies the core requirements that provide the foundation for ESH&Q management at BNL. BNL used the cross-reference between the ISM Principles and Core Functions provided in the former DOE Manual 450.4-1, Integrated Safety Management System Manual and the Quality Assurance (QA) Criteria provided in the DOE Guide 414.1-2A, Quality Assurance Management System Guide to aid in developing the BNL ISMS Program. The ISMS Program continues to employ an integrated set of non-overlapping management systems that embody the requirements defined in DOE P 450.4A, Safety Management System Policy. These systems collectively form the Standards-Based Management System (SBMS) management systems, BNL's highest level of operating and business processes that define how work is conducted at the Laboratory. These management systems are

  - ISM Program Description describes BNL's programs for accomplishing work safely and provides the road map of the systems and processes that make up the BNL Integrated Safety Management System (ISMS)

Integrated Safety Management System (ISMS)

- Management systems that are key elements in ISMS for all work at BNL are defined within the management system descriptions which include:
  - Acquisition Management
  - Emergency Preparedness
  - Environmental Management System
  - Facility Operations
  - Facility Safety
  - Integrated Assessment Program
  - Integrated Planning
  - Occupational Medicine
  - Project Management
  - Radiological Control
  - Real Property Asset Management
  - Training and Qualifications
  - Work Planning and Control
  - Worker Safety and Health