Scientific computing at BNL

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70 YEARS OF **DISCOVERY**

A CENTURY OF SERVICE

U.S. DEPARTMENT OF **ENERGY**   **BROOKHAVEN** NATIONAL LABORATORY

LHCOPN-LHCONE meeting - BNL

BNL is a Data Driven Science Laboratory

- **BNL is dominated by Data-rich Experimental Facilities:**
  - **RHIC** - Relativistic Heavy Ion Collider - High Energy Physics Experiment supporting over 1000 scientists world wide
  - **NSLS II** - Newest and Brightest Synchrotron in the world opened in the world, supporting a multitude of scientific research in academia, industry and national security
  - **CFN** - Center for Functional Nanomaterials, combines theory and experiment to probe materials

- **BNL supports large scale Experimental Facilities:**
  - **STAR/PHENIX -** the RHIC experiments
  - **LHC Atlas -** Largest Tier One Center outside CERN, data storage and processing
  - **ARM** - Atmospheric Radiation Measurement Program - Partner in multi-side facility, operating its external data Center
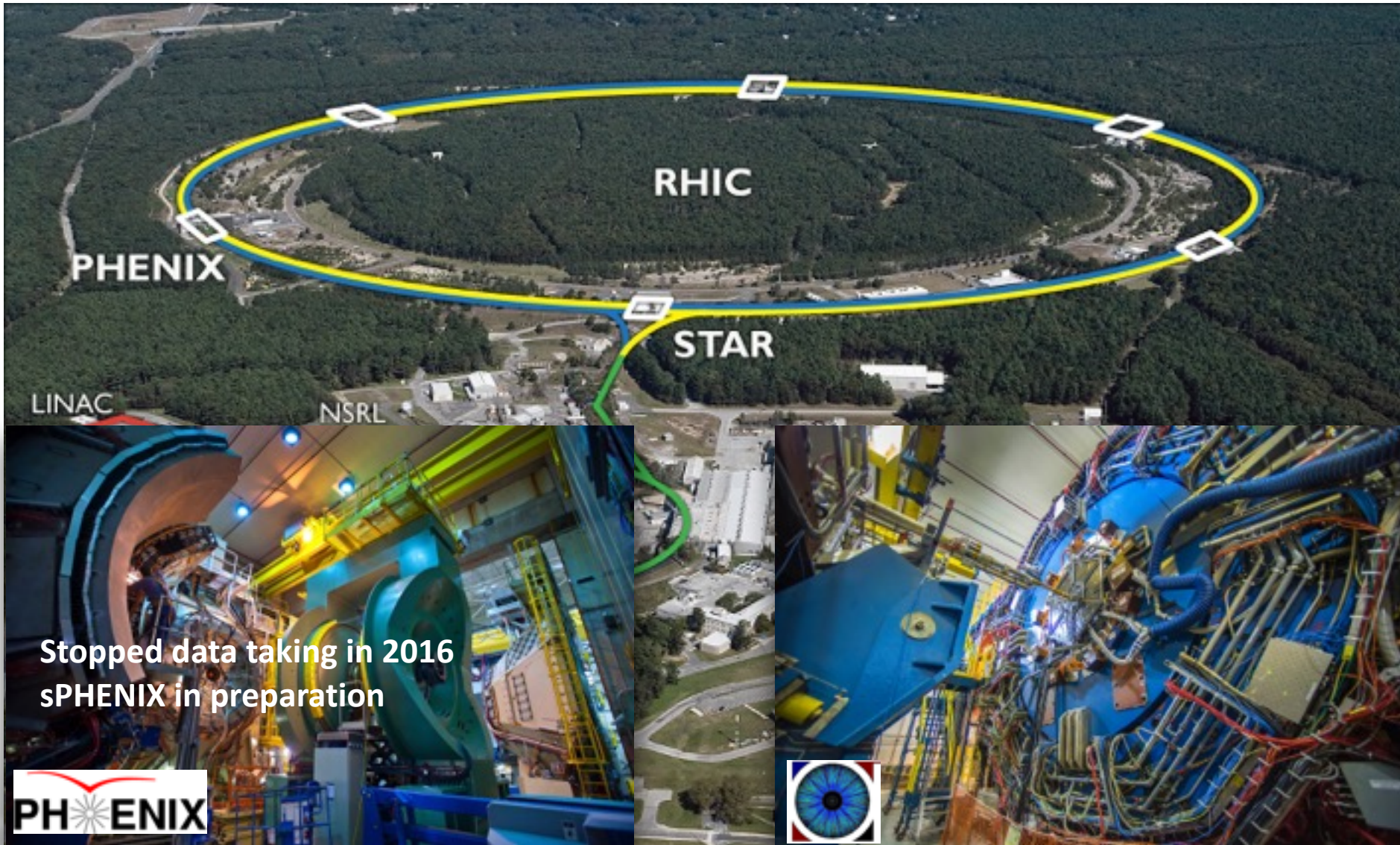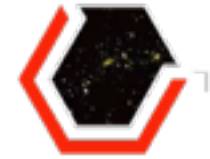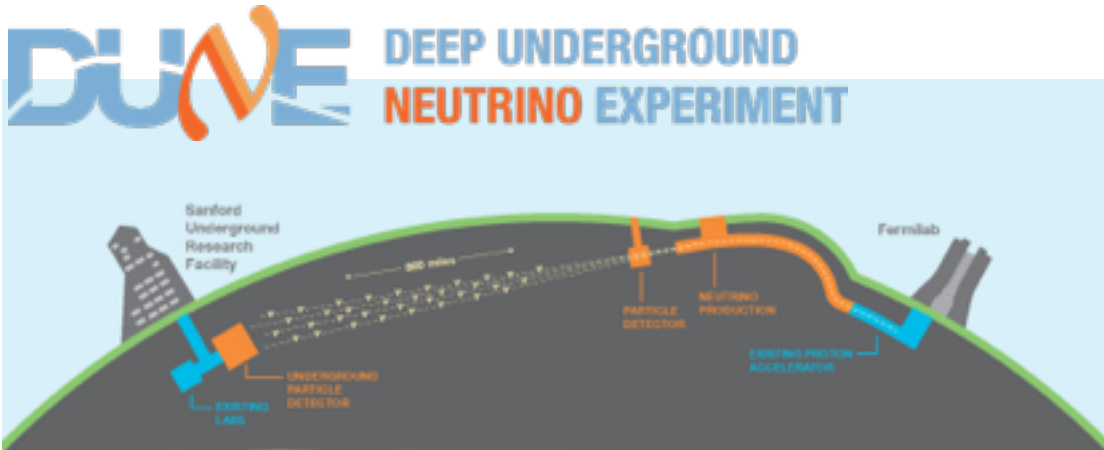

RHIC

NSLS II

CFN

LISF

SDCC

U.S. DEPARTMENT OF ENERGY

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Some of the facilities on BNL site

National Synchrotron Light Source II

NSLS - II

The Center for Functional Nanomaterials

B725
CFR Site

CFN

Interdisciplinary Science Building

ISB

Physics Dept.
(RACF)

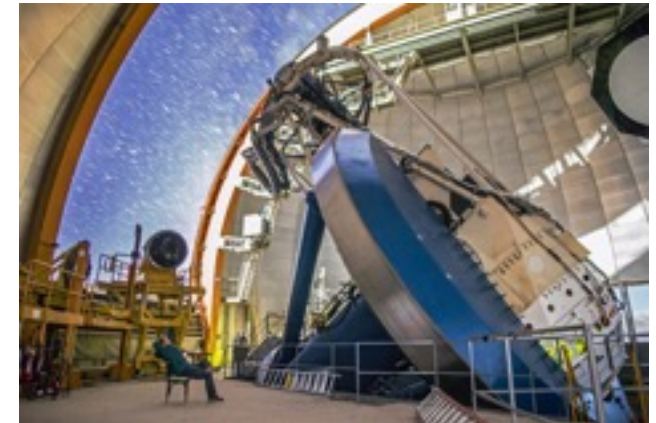# RHIC: 2 main experiments PHENIX & STAR

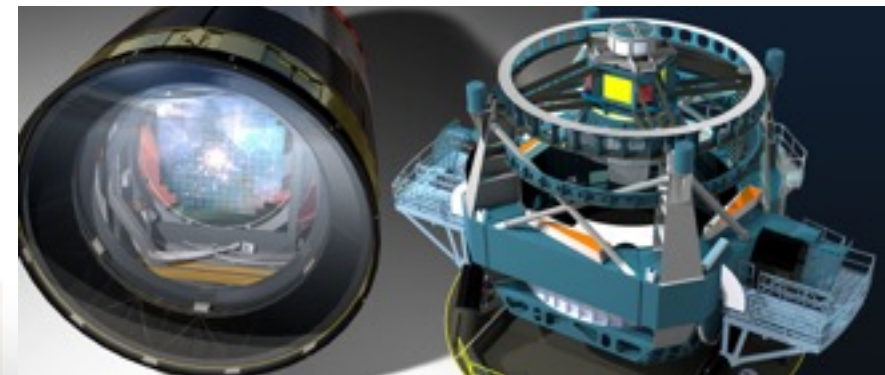Stopped data taking in 2016
sPHENIX in preparation

Some of the current and future experiments of the physics department

Dark Energy Survey

Large Synoptic Survey Telescope (LSST)

Scientific Data and Computing Center

- **Service Operation For:**
  RHIC, LHC Atlas, BER ARM, LQCD, RIKEN, BES Center for Functional Nano Materials, National Synchrotron Light Source II, National Nuclear Data Center, Simons Foundation
  - **17 Data Services, 1000's of users**

SDCC end of 2016

BNL Cloud
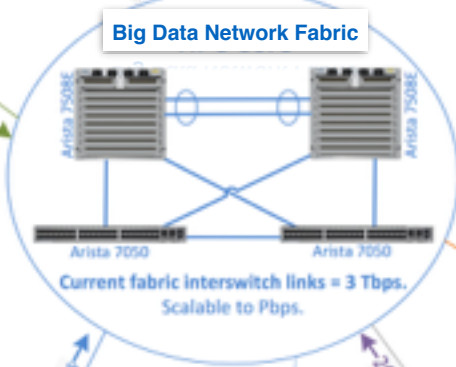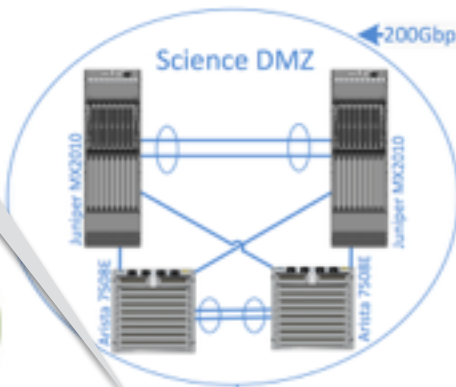Used by OSG, ATLAS and various groups from BNL outside physics department

ATLAS

Science DMZ

200Gbps

ESnet
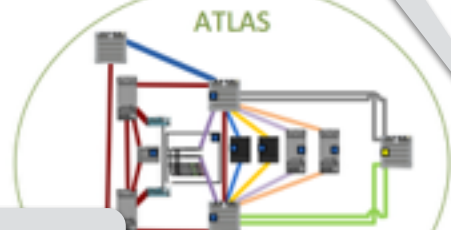
KNL cluster

HTC CPU = 15,000 cores
Disk storage = 15 PB

RHIC

Big Data Network Fabric

Arista 7508E   Arista 7508E

Arista 7050   Arista 7050

Current fabric interswitch links = 3 Tbps.
Scalable to Pbps.
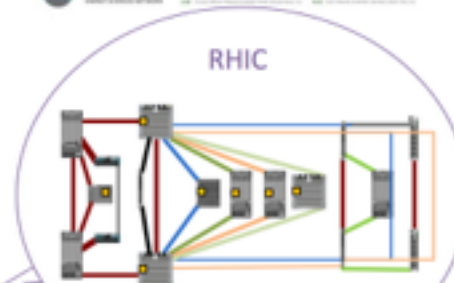
HTC CPU = 35,000 cores
Disk storage = 25 PB

RHIC Facilities

Tape Mass Storage

CFN TEM

HPC Institutional Cluster

(2017 : USQCD cluster)

Institutional Cluster
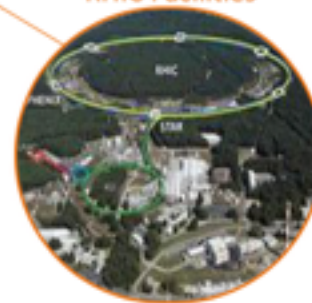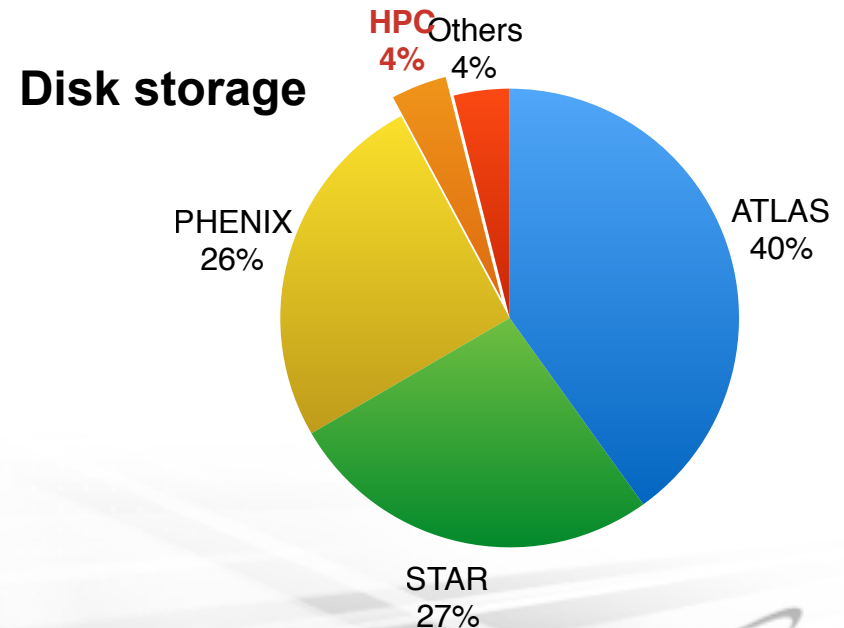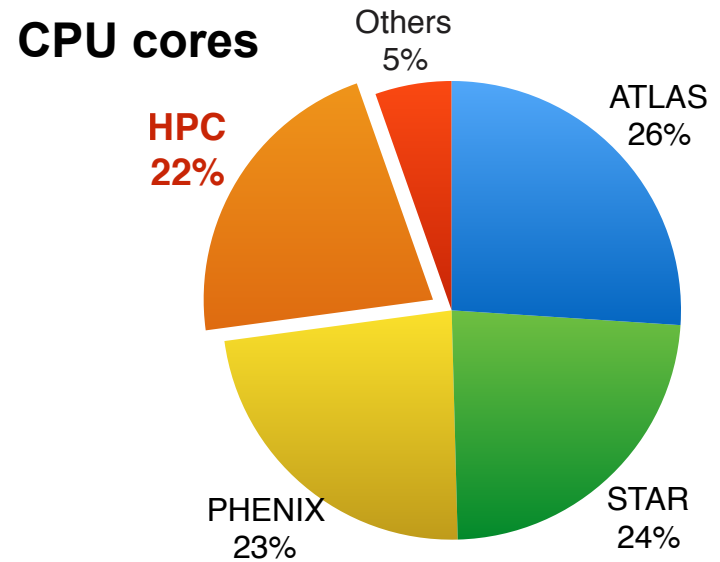
SDCC in numbers

- **70k CPU cores (~100k in 2017)**
  - 2017: HPC *1/3* of capacity

HPC CPU cores [%]
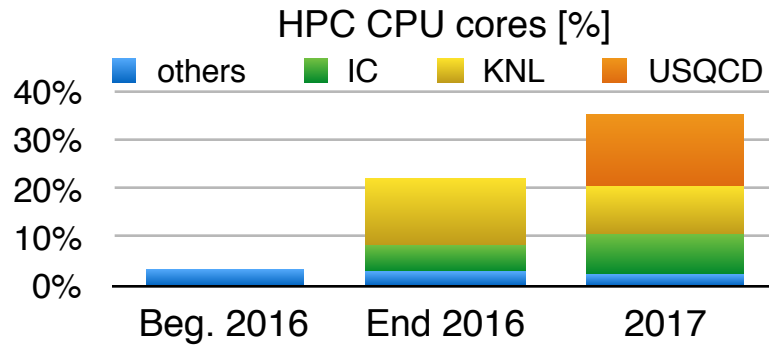
- **~50 PB of disk storage**
  - of various technologies

- **~100 PB of tape storage**
  - Largest HPSS tape library in the US, 4th worldwide [1]

- **2x100 Gbps connection to ESNet**
  - Onsite ESNet support

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

CPU cores

- Others 5%
- HPC 22%
- ATLAS 26%
- STAR 24%
- PHENIX 23%

Disk storage

- HPC 4%
- Others 4%
- ATLAS 40%
- PHENIX 26%
- STAR 27%

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High Throughput Parallel Archiving

RHIC RUN 16 - STAR

STAR Data Transfer View
Range: 2016-04-07 14:28:00 - 2016-04-09 14:23:00
RAW Write: 215.3 TB, 62303 files, avg size: 3.54 GB, avg rate: 1.28 GB/s
DST Write: 20.51 TB, 7218 files, avg size: 2.91 GB, avg rate: 124.44 MB/s
RAW Read: 95.03 TB, 23407 files, avg size: 4.16 GB, avg rate: 576.66 MB/s
DST Read: 7.24 TB, 64652 files, avg size: 117.45 MB, avg rate: 43.94 MB/s

Data Injection: Average 1.28 GB/s in 48 Hours! (Green)

Data Restore: Average 576 MB/s in 48 Hours! (Blue)
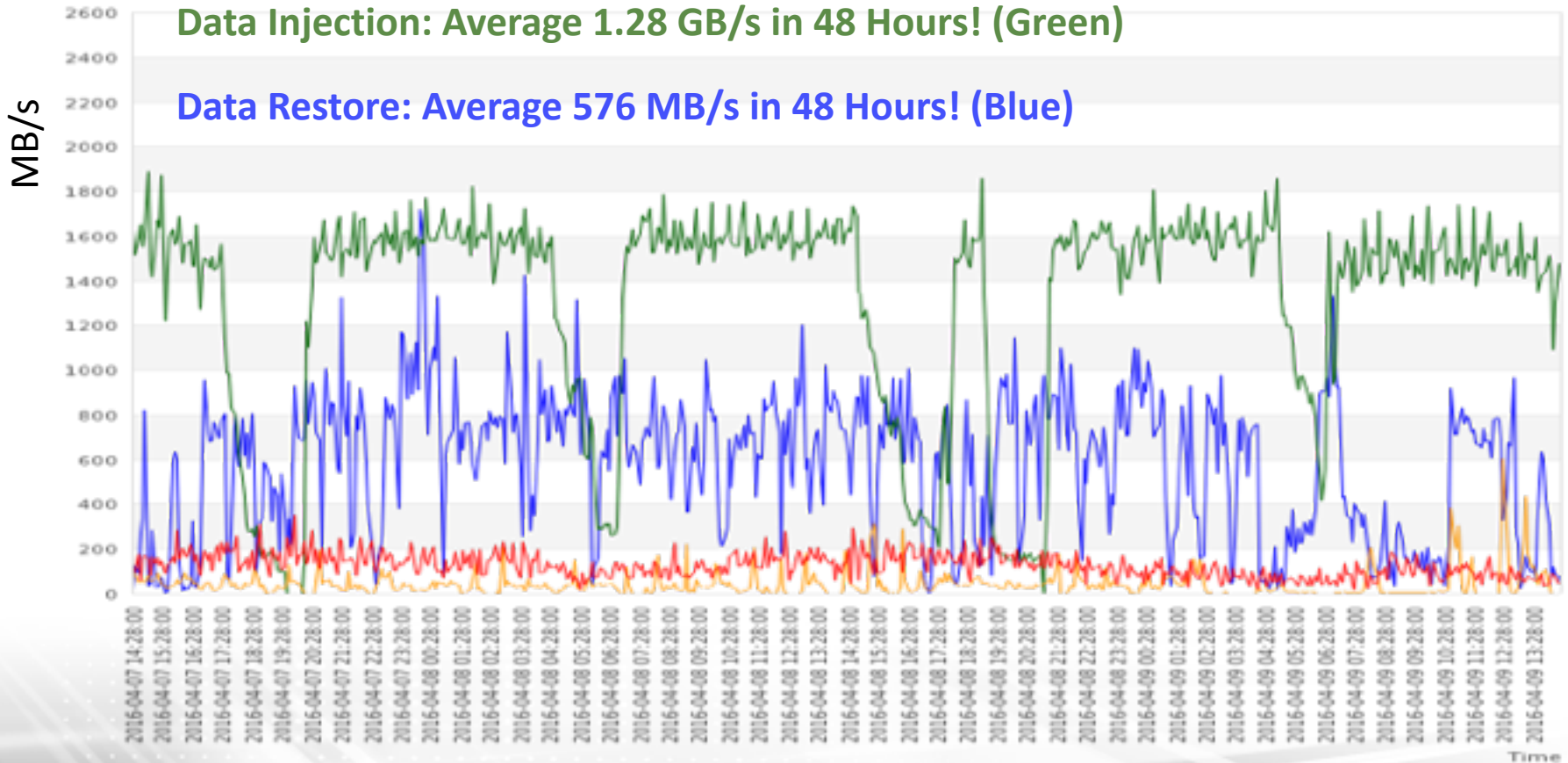
SDCC and RHIC and ATLAS experiments

- **The RHIC Tier 0**
  - Store and process data from RHIC experiments
  - Provide analysis means for 1'200 users
  - Long term data preservation
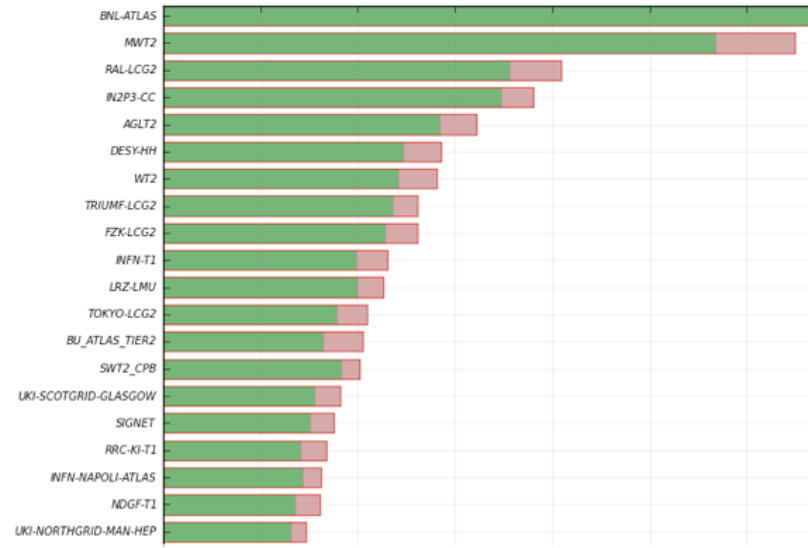 - Simulation resources for future programs (sPHENIX & EIC)

- **The US ATLAS Tier 1**
  - ~25% of ATLAS Tier 1 computing capacity worldwide
  - Store RAW data from LHC and from simulation
  - Distribute data to the 4 US Tier 2 sites + analysis site (SLAC)
  - Analysis center for US physicists
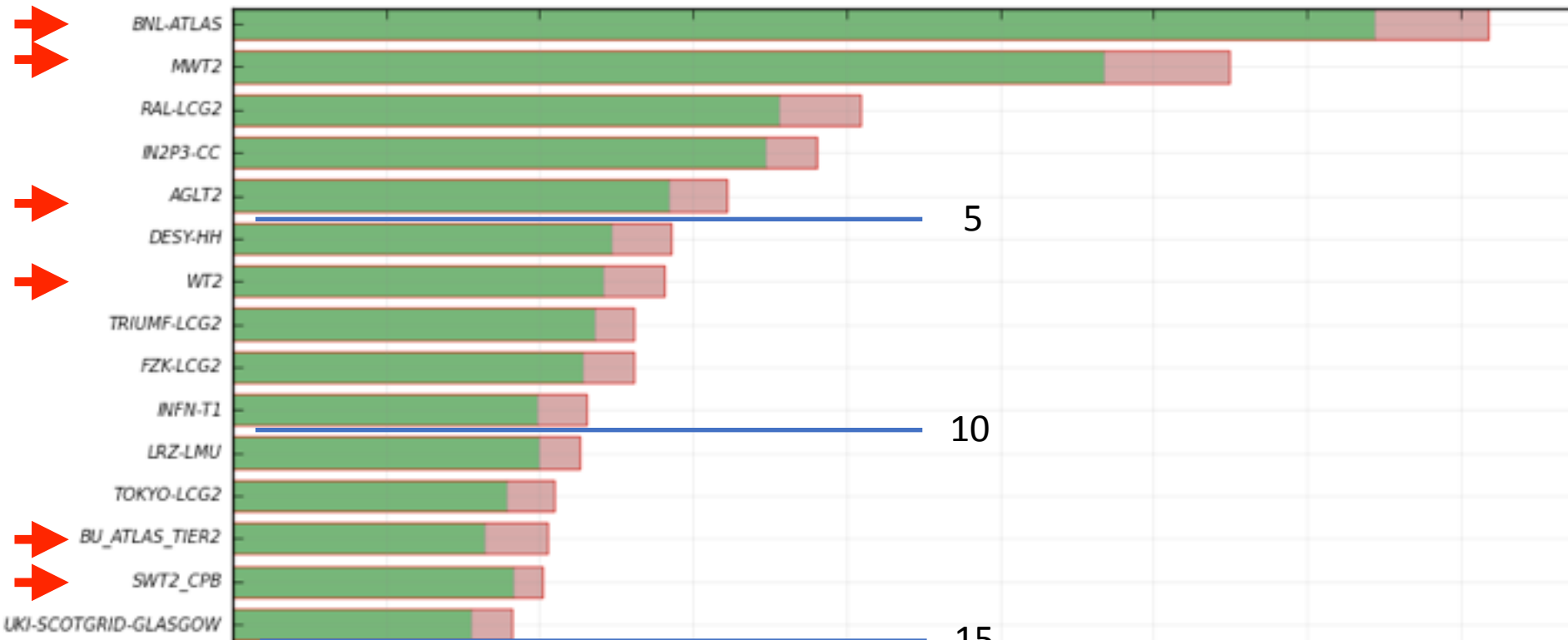   - From 41 institutes (incl. 4 Nat. Labs)
    - 600 physicists, 190 PhDs

CPU delivered to ATLAS by sites in 2016

All sites

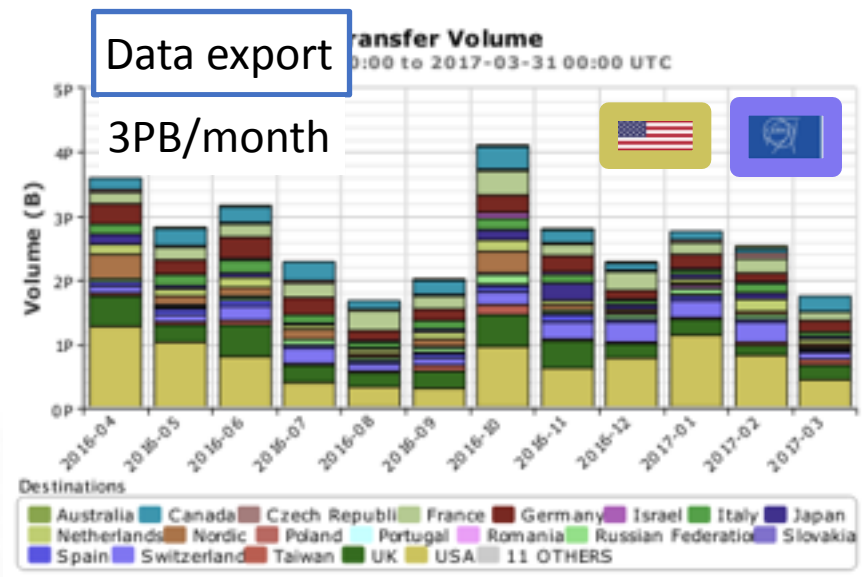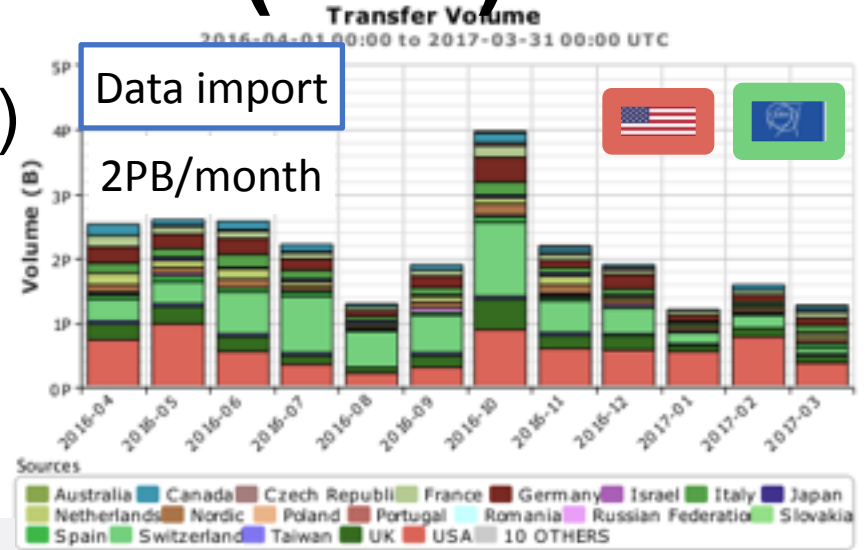# CPU delivered to ATLAS by sites in 2016

The first 15

ATLAS: Data transfers (FTS)

- Over a year (since Apr. 2016)
  - Data import : 25 PB
  - Data export : 35 PB
  - 175 PB processed

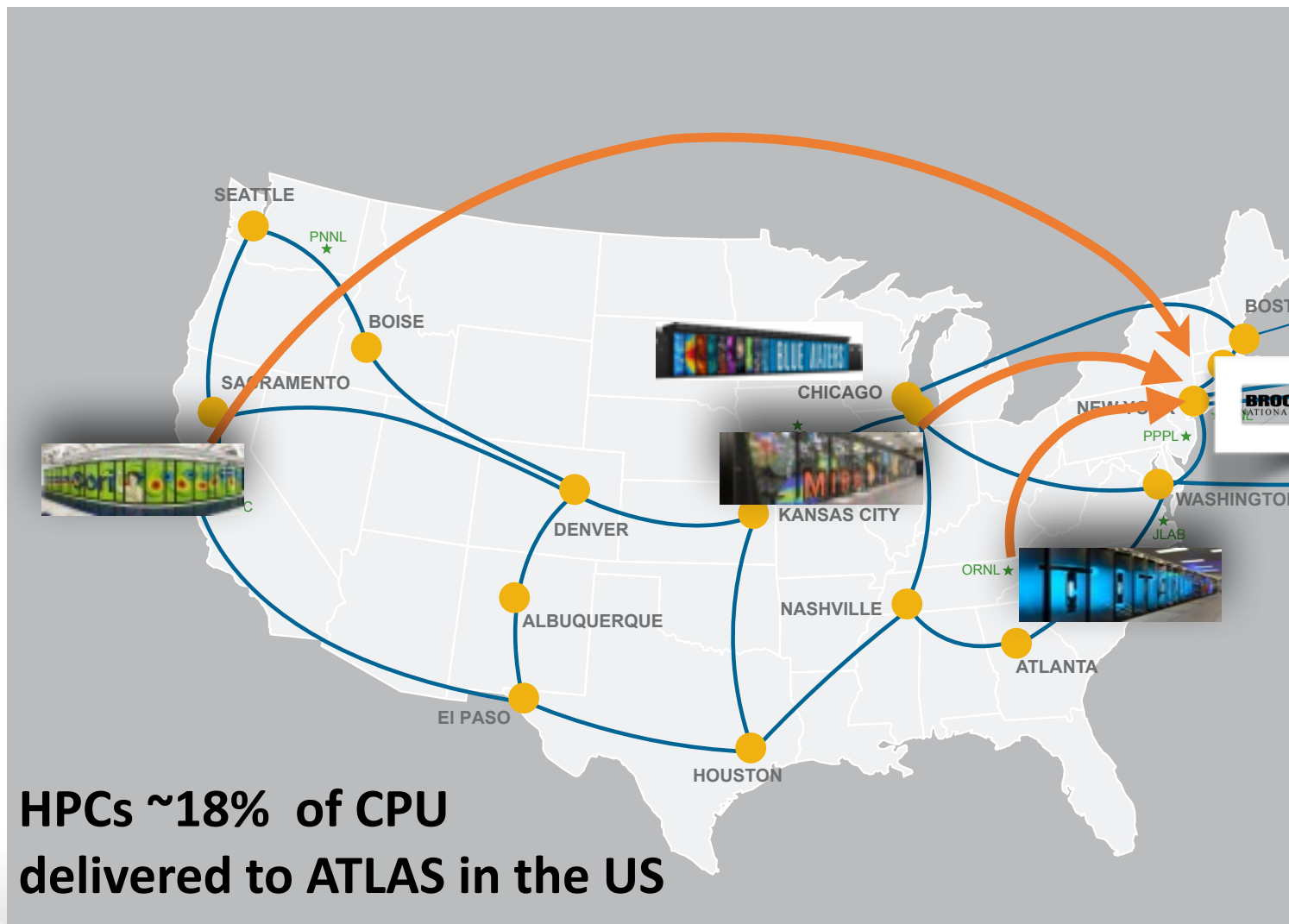# ATLAS: Data transfers (FTS)

- Over a year (since Apr. 2016)

ATLAS: BNL and HPCs

**HPCs ~18% of CPU
delivered to ATLAS in the US**

Data produced at HPCs stored mostly at BNL
and small fraction through FTS

National Synchrotron Light Source II (NSLS-II)

Visit tomorrow morning at coffee break

NSLS-II: Science Driven Data Challenges

- **Brightest synchrotron in the world**
    - 2,000 users per year (4,000 in FY17) - 2/3 from Universities
    - 16 beamlines operational at present, full build out 60
    - Supports Multitude of Sciences - Physics, Chemistry, Biology, Climate, Bio-Medical …
- **Data Challenges:**
    - NSLS II - Coherent Hard X-Ray (CHX) Beamline 4.5 GB/s sustained data rates
    - NSLS II - Hard X-Ray Nanoprobes (HXN) 50 GB/s sustained, 1 – 5 TB/s in burst
    - High Data Velocity, Real Time, Correlated Events, Reliability Requirements
- **Needed data driven real time steering of experiments**
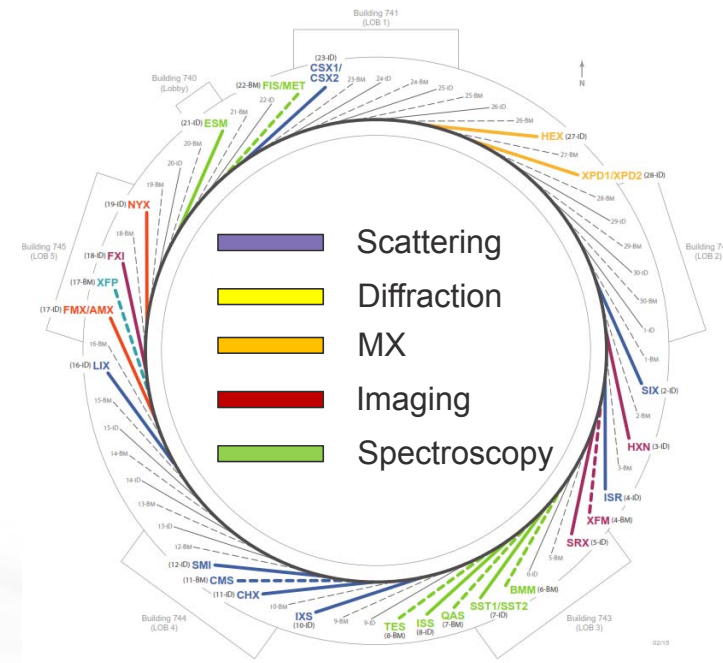
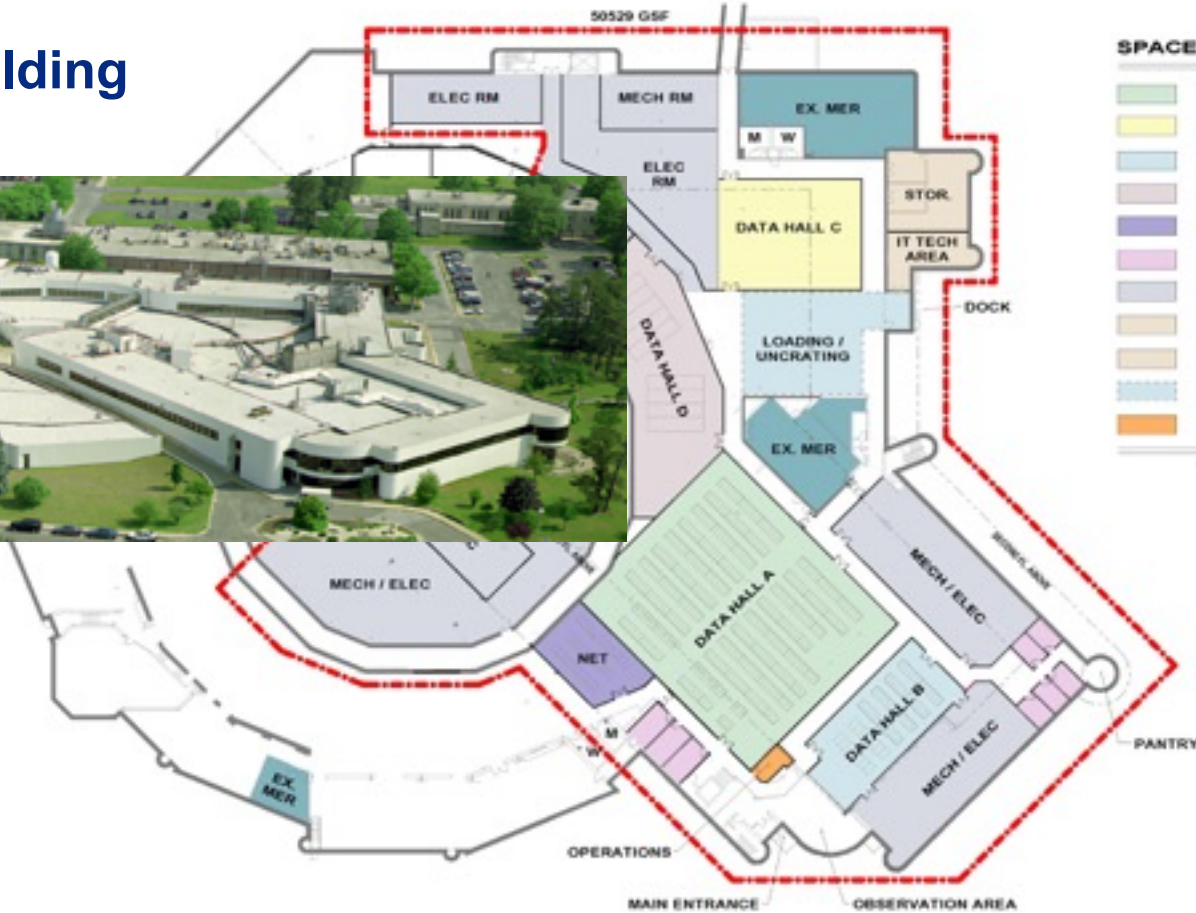# Estimated NSLS-II Storage Needs

PB/y
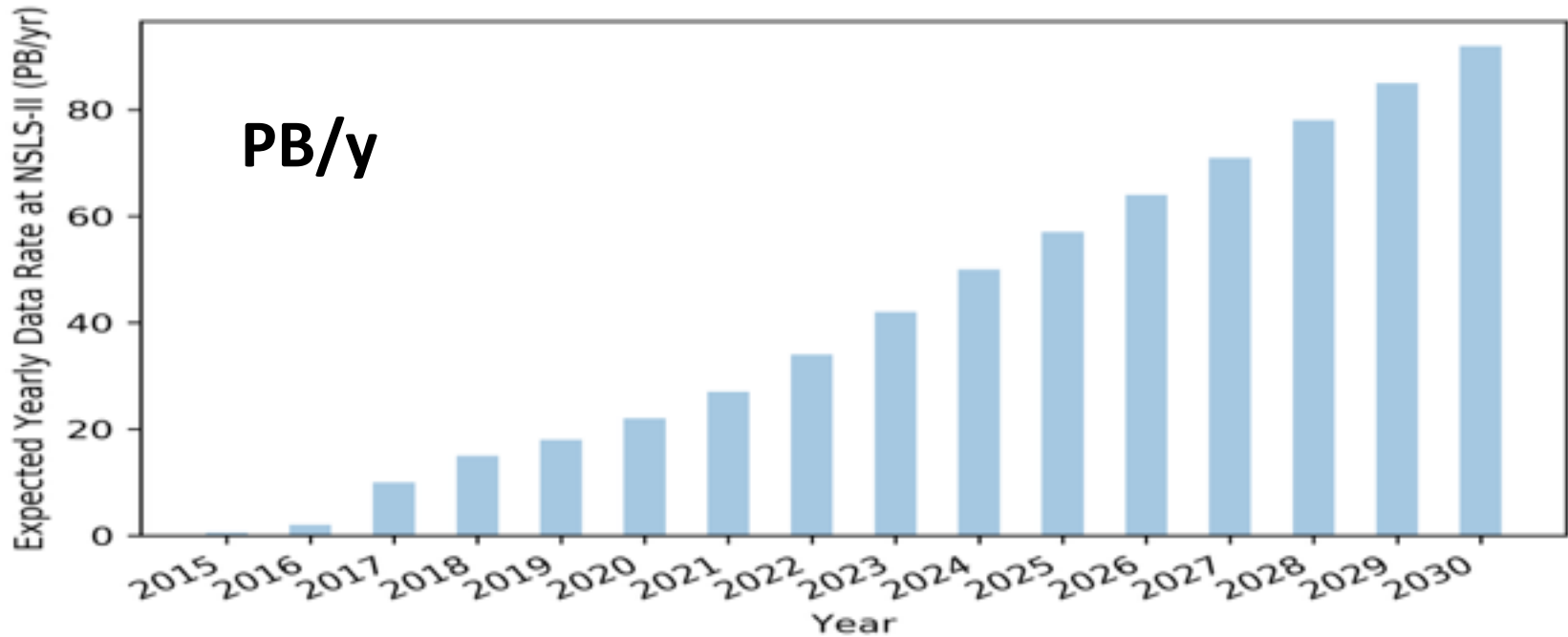
- Estimated for the 28 NSLS-II beamlines under development
- Based on current information on operating beamlines
- Takes into account estimated increases in both detector and beamline operational reliability.

New Data Center (FY22)

NSLS-I Building

SPACE LEGEND

		PROGRAM NET AREA (NSF)	DELINEATED AREA (NSF)
	DATA HALL A		
	DATA HALL B		
	DATA HALL C		
	DATA HALL D		
	NETWORK EQUIPMENT		
	OFFICES		
	MECH/ELEC		
	IT TECH AREA		
	STORAGE		
	LOADING / UNCRATING		
	OPERATIONS		
	TOTAL NET AREAS		

Phase I : 60% Space Plan, 3.6 MW

~3.5 x today's capacity

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

CD-1 review August 23-25, 2016

Summary and Outlook

- Successfully meet computational needs of US ATLAS and RHIC programs
    - a world class big-data processing facility
    - close to the users and responsive to their needs

- Expending capacities for
    - integration of National Nuclear Data Center, Atmospheric Radiation Measurement, NSLS-II,…

- Rapid growth adding HPC capabilities

- Challenging and exciting years in front of us!