DUNE Computing Capacity Requirements

Michael Kirby, Fermilab/Scientific Computing Division

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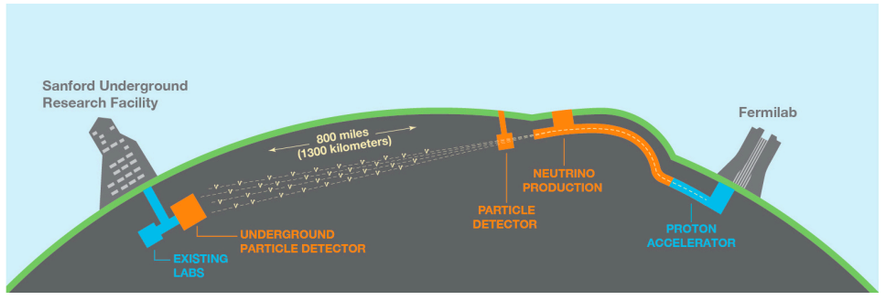
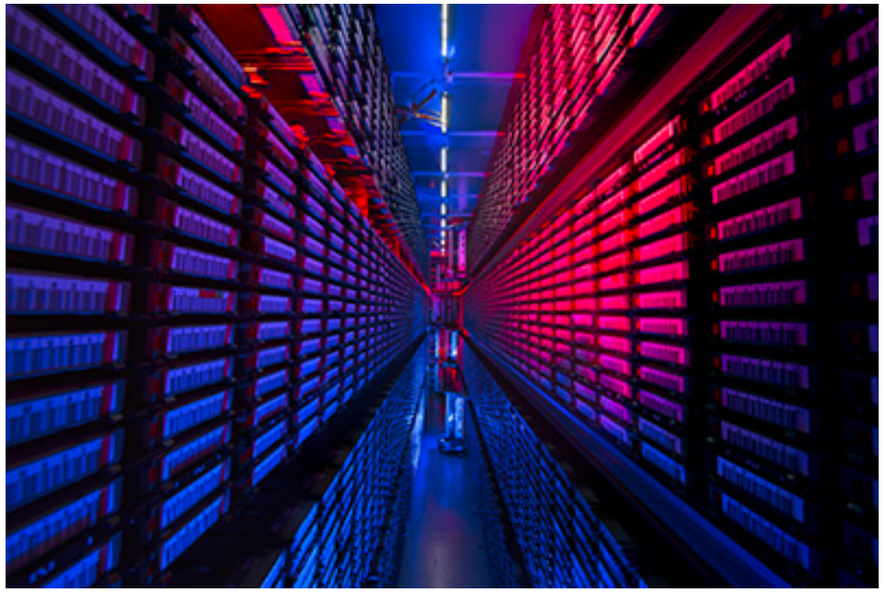
Outline

- development of the Resource Requirement Document
- general overview of computing plan (2020-2022)
- protoDUNE operation assumptions
- estimated resource requests
- discussion





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Fermilab Computing Resource Scrutiny Group

- Fermilab CRSG review occurred May 4-5, 2020
- CRSG review of resource requests from FNAL experiments (DUNE, NOvA, Mu2e, etc)
- reviewed DUNE computing model and resource projections for 2020-2022
- commended FNAL and DUNE on choice of Rucio for Data Management
- emphasized importance of data lifetime policy
- focus on dCache (disk) usage requests
- stated that experiment resource requests were reasonable
- may want to delve deeper into the larger experiment resource justifications

General Plan for DUNE Computing 2020 - 2022

- Support the operation and analysis of protoDUNE SP and DP in 2020 (non-beam data) through disassembly for protoDUNE II
  - archive of raw, derived, and simulated data - successful keep-up of data taking
  - production processing of SP and DP data twice per year - PD-SP Prod4 has begun
  - production processing of simulation for SP and DP - all sim requests for PD complete
  - there have been limited requests for simulation over the last 9 months
- Support the DUNE Far and Near Detector for design and sensitivity improvements
  - simulation of FD and ND samples - DUNE TDR published - ND CDR posted on arXiv
  - sensitivity studies for detector improvements and reviews
- Utilize the OSG, WLCG, and additional compute resources when available - 4 new sites
- Improve access to HPC resources for specific analysis workflows and production workflow development

How do we estimate our raw data volume?

ProtoDUNE II Data Volume

- uncompressed SP data Run I - 178 MB/evt
  - expected from 3 ms of 6 APAs
  - 20% overhead - other PDS and headers
  - compressed SP data - 71 MB/evt
  - compression factor of 2.5
- uncompressed DP data Run I - 110 MB/evt
  - 2 CRPs readout - 4 CRPs full detector
  - compression factor of 10 expected in 2021-2022

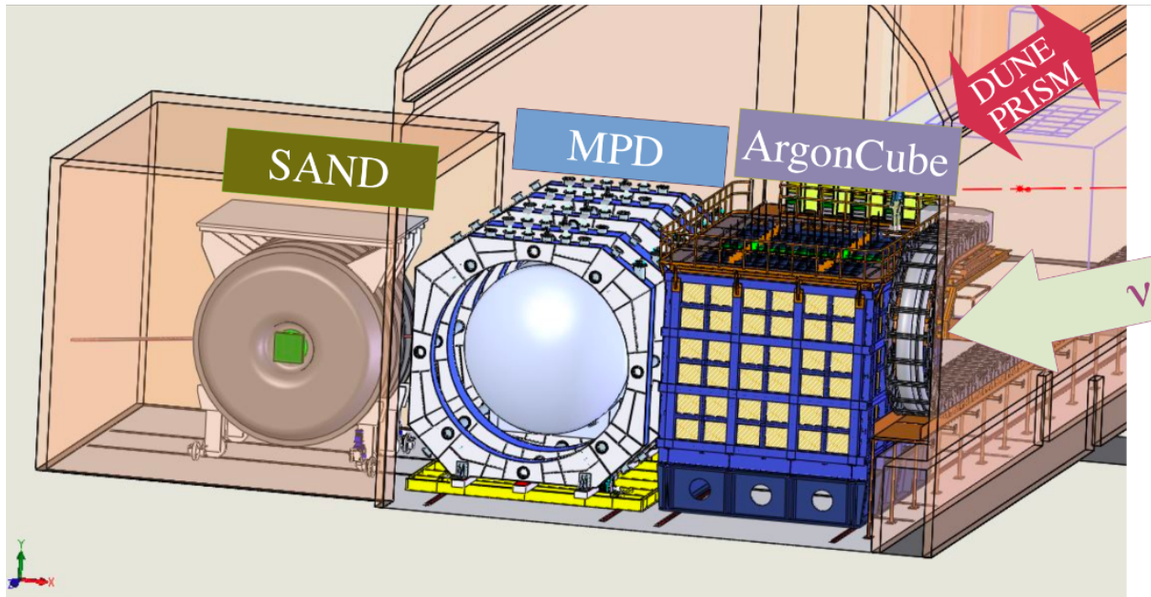
Far Detector Data Volume

- Single Phase FD Module scaled from the ProtoDUNE SP
  - scale readout 6 —> 150 APA
  - scale readout 3 ms —> 5.4 ms
  - compression factor of 2.5 for standard operations
  - assume start commissioning of one SP-FD module in 2026
  - assume start commissioning of one DP-FD module in 2028

How do we estimate our raw data volume?

Near Detector Data Volume

- incorporated from the ND Conceptual Design Report
- ND LAr Detector
  - TPC - 3 MB/spill
  - Photon Detector System - 5 MB/spill
  - assume compression of 3 - 2.6 MB/spill
- ND GAr Detector
  - Gas TPC - 2 MB/spill
  - ECAL - 1 MB/spill
  - both uncompressed



- SAND 3D Scintillator Tracker
  - 0.3 MB/spill
- 10 MB/spill raw data total
- assumptions 5% downtime of each subdetector

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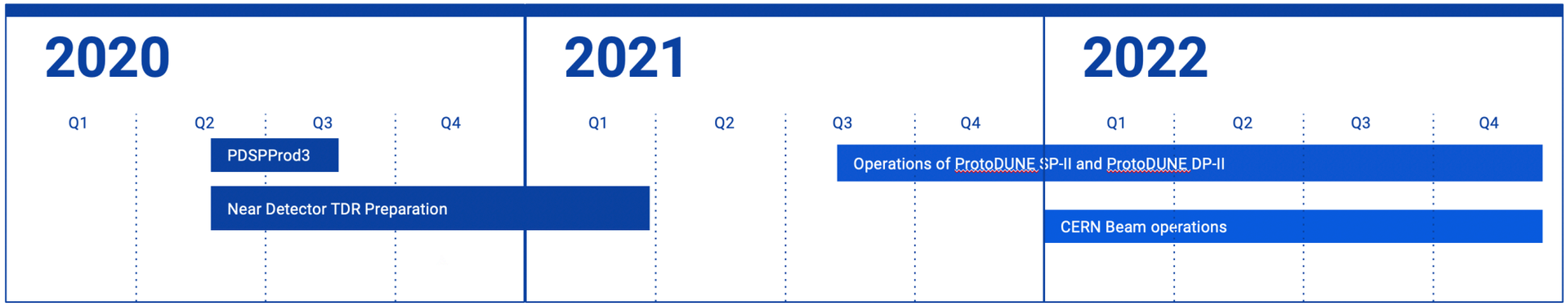
Beam and Cosmic Operations assumptions



- ProtoDUNE II
  - 150 days of cosmic running in 2020/2021/2023 - both SP (6.5 M evts) and DP (21.6 M evts)
  - 50 days of beam in 2021 and 2022 - both SP (17 M evts) and DP (40 M evts)
  - cosmic running in 2022 - SP (300 days - 13 M evts) and DP (200 days - 24.4 M evts)
- Commissioning of one SP-FD module begins with 150 APAs in 2026
- Commissioning of one DP-FD module begins in 2028
- “ProtoND” operations in 2022 and 2023
- Commissioning of ND starts in 2028

Reconstructed data volume and processing

- Reconstruction algorithms for ProtoDUNE are well defined (three successful campaigns)
- dropping waveforms/raw data after reconstruction leads 10x reduction from raw volume - FD 100x reduction
- run time is 600 s/evt for both SP and DP
  - 180 s/evt his finding
  - 420 pattern recognition
  - matching performance found on WLCG/ OSG worker nodes
- ND reco data estimate equal to raw data
- ND reconstruction estimate 172 s/evt

- ProtoDUNE Simulation - 10 M evts
  - 2700 s/evt current experience
  - 200 MB/evt current experience
- FD simulation - 10 M evts
  - 2700 s/evt from ProtoDUNE
  - 200 MB/evt
- ND simulation
  - 25 M evts 2021
  - 10 M evts - 2022 - 2025
  - 50 M evts - 2026 —>2030
  - 300 s/evt (2.5 x CPU for data)
  - 20 MB (2x data reco/evt)

Data Retention Policies

- Tape Storage
- two copies of all raw data for security
  - FNAL provides storage for an archival copy of all raw data (ND, FD, ProtoDUNE)
  - Rucio Storage Elements (RSEs) around world provide tape storage for 2nd copy
  - test data retained for 6 months
  - one copy of all reconstructed data indefinitely
    - ProtoDUNE, FD, ND
  - one copy of all simulated data indefinitely
    - ProtoDUNE, FD, ND

- Disk Storage
  - raw data disk lifetime is dictated by production processing schedule
  - reconstruction derived dataset has a disk lifetime of two years
  - simulation has a disk lifetime of two years
  - reconstruction and simulation datasets will be available from two institutions
  - FNAL provides disk for reconstructed data derived dataset
- From these policies can model the tape and disk modeling

Computing Model and Data Model Policies

- ProtoDUNE
  - reconstruction processing twice/year
  - four active data datasets on disk
  - simulation processing once/year
  - two active MC datasets on disk
  - production processing continues though 2025 when datasets are frozen
- DUNE Far Detector
  - reconstruction processing twice/year
  - process full dataset - not seen til 2030
  - simulation processing once/year
  - if data lifetime is shorter than 10 years, effect not seen in model
- DUNE Near Detector
  - reconstruction processing twice/year
  - process full dataset - not seen until 2030
  - simulation processing once/year
- Can estimate tape, disk, and CPU usage for each year
- analysis CPU estimated as equal to production processing
- analysis storage is considered < 10% perturbation

ProtoDUNE SP and DP Operations and Raw Data

protoDUNE Single Phase	2020	2021	2022
cosmic rate (Hz)	1	1	1
beam rate (Hz)	0	5.6	5.6
uptime (days)	150	150+50	300+50
events	6.5 M	24 M	30 M
event size (MB)	173	173	173
compression	2.5	2.5	2.5
yearly data (TB)	450	1625	2070

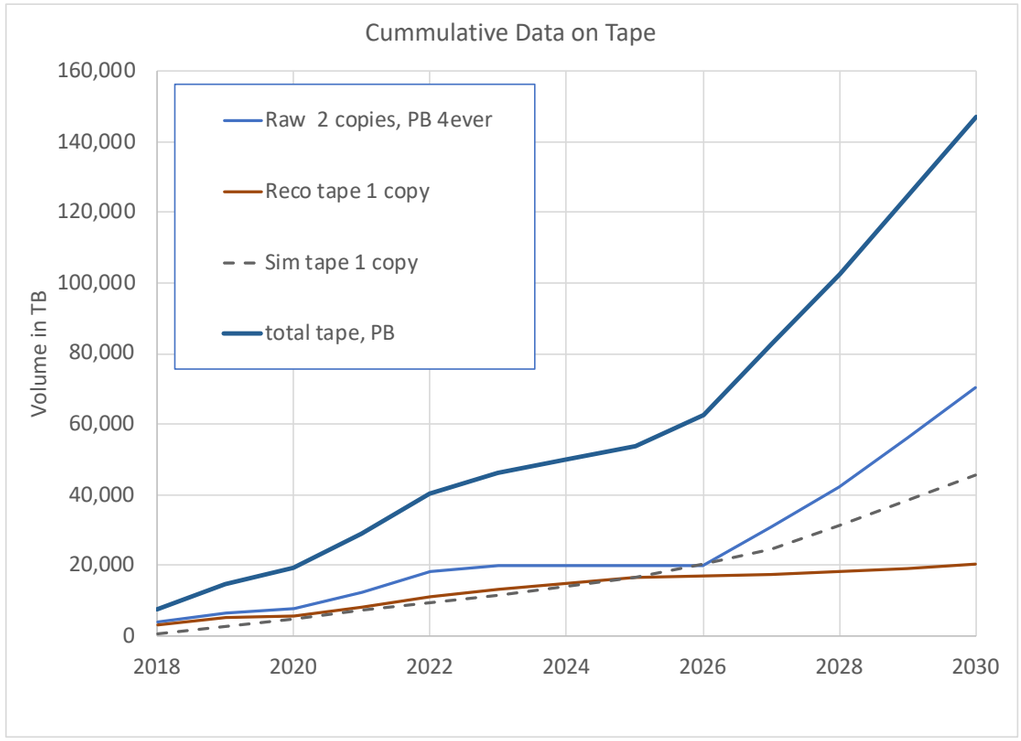
protoDUNE Dual Phase	2020	2021	2022
cosmic rate (Hz)	5	1	1
beam rate (Hz)	0	18.3	18.3
uptime (days)	100	150+50	300+50
events	21 M	62 M	65 M
event size (MB)	110	110	110
compression	10	10	10
yearly data (TB)	240	681	710

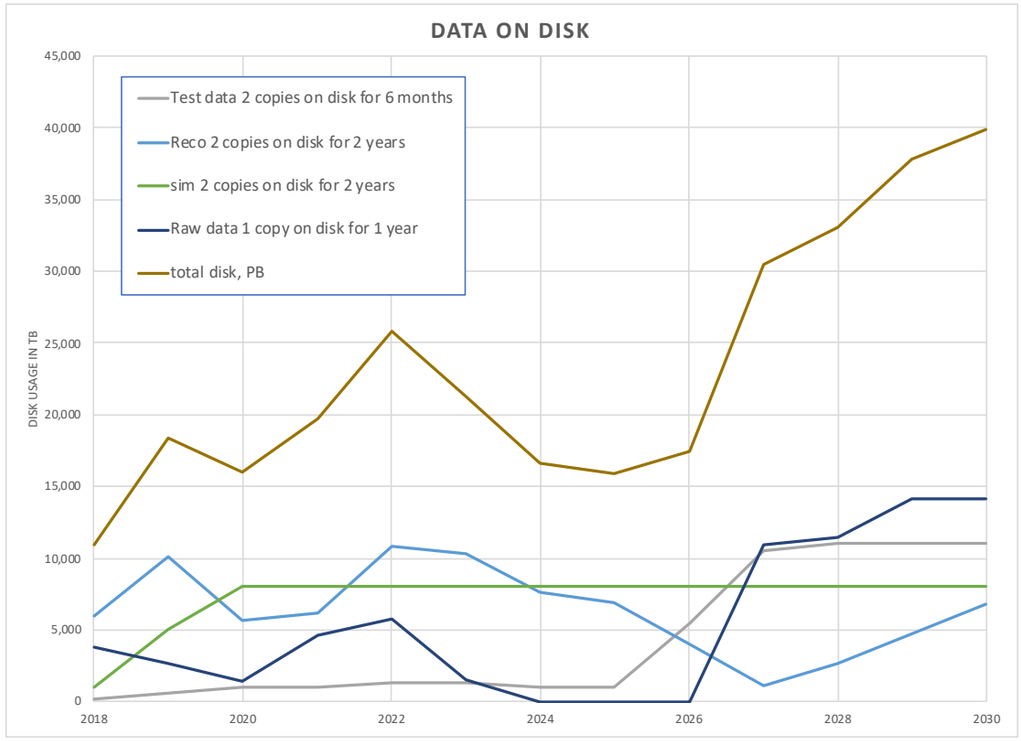
DUNE ND Simulation Data Volume

Near Detector Simulation	2020	2021	2022
events	10 M	25 M	10 M
event size (MB)	20	20	20
yearly data (TB)	200	500	200
CPU (MHrs)	1	3	1.2

Near Detector Prototypes	2022	2023	2024
events	10 M	10 M	0
event size (MB)	10	10	10
yearly data (MB)	100	100	0
test data (MB)	300	300	0
derived data (MB)	200	200	200
CPU (MHrs)	0.3	0.3	0.3

Tape and disk storage 2018-2030





- Computing Model for DUNE Storage
  - 2 archival copies of raw, 1 for derived & simulated data - 1 copy at FNAL, second copy distributed institutions
  - production processing of SP and DP data twice per year and once matching simulation
  - 4 copies of active derived and simulated datasets on disk - dataset stays active for 2 year

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DUNE CPU requirements

protoDUNE Single Phase	2020	2021	2022
data events	6.5 M	24 M	30 M
CPU (hr)	1 M	4 M	5 M
MC events	5 M	5 M	5 M
CPU (hr)	3.8 M	3.8 M	3.8 M
analysis (hr)	5 M	8 M	9 M
Total CPU (hr)	13.8 M	16 M	17 M
Total CPU (HS06 years)	15750	18260	19400

protoDUNE Dual Phase	2020	2021	2022
data events	21 M	62 M	64 M
CPU (hr)	3.5 M	10.5 M	10.8 M
MC events	5 M	5 M	5 M
CPU (hr)	3.8 M	3.8 M	3.8 M
analysis (hr)	8 M	14.3 M	14.6 M
Total CPU (hr)	15.3 M	28 M	29 M
Total CPU (HS06 years)	17470	32000	33100

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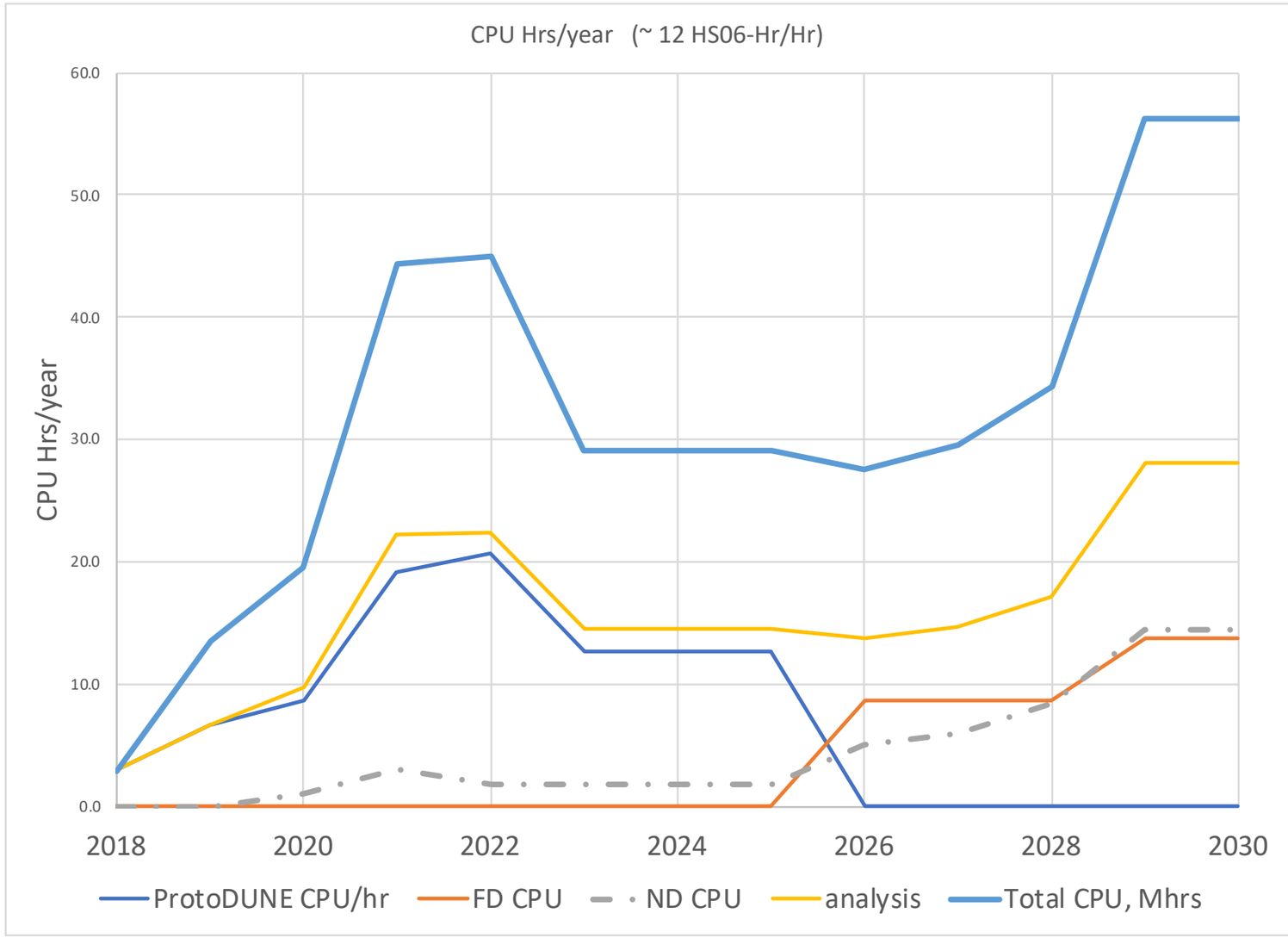
- SP Data 0.16 hr/evt - SP MC 0.75 hr/evt - DP 0.16 hr/evt - DP 0.75 hr/evt

Total DUNE Resource Needs

Resource	2020	2021	2022
Disk (PB)	16	20	26
Tape (PB)	19	29	40
CPU (kHS06-years)	33.1	50.2	52.5
CPU Cores	2200	3460	3540

CPU Resources 2018 - 2030

- ProtoDUNE CPU needs dominate for the foreseeable future
- May actually be larger than FD requirements
- Near Detector CPU needs for reconstruction and simulation become significant in 2026 and will content with FD CPU needs



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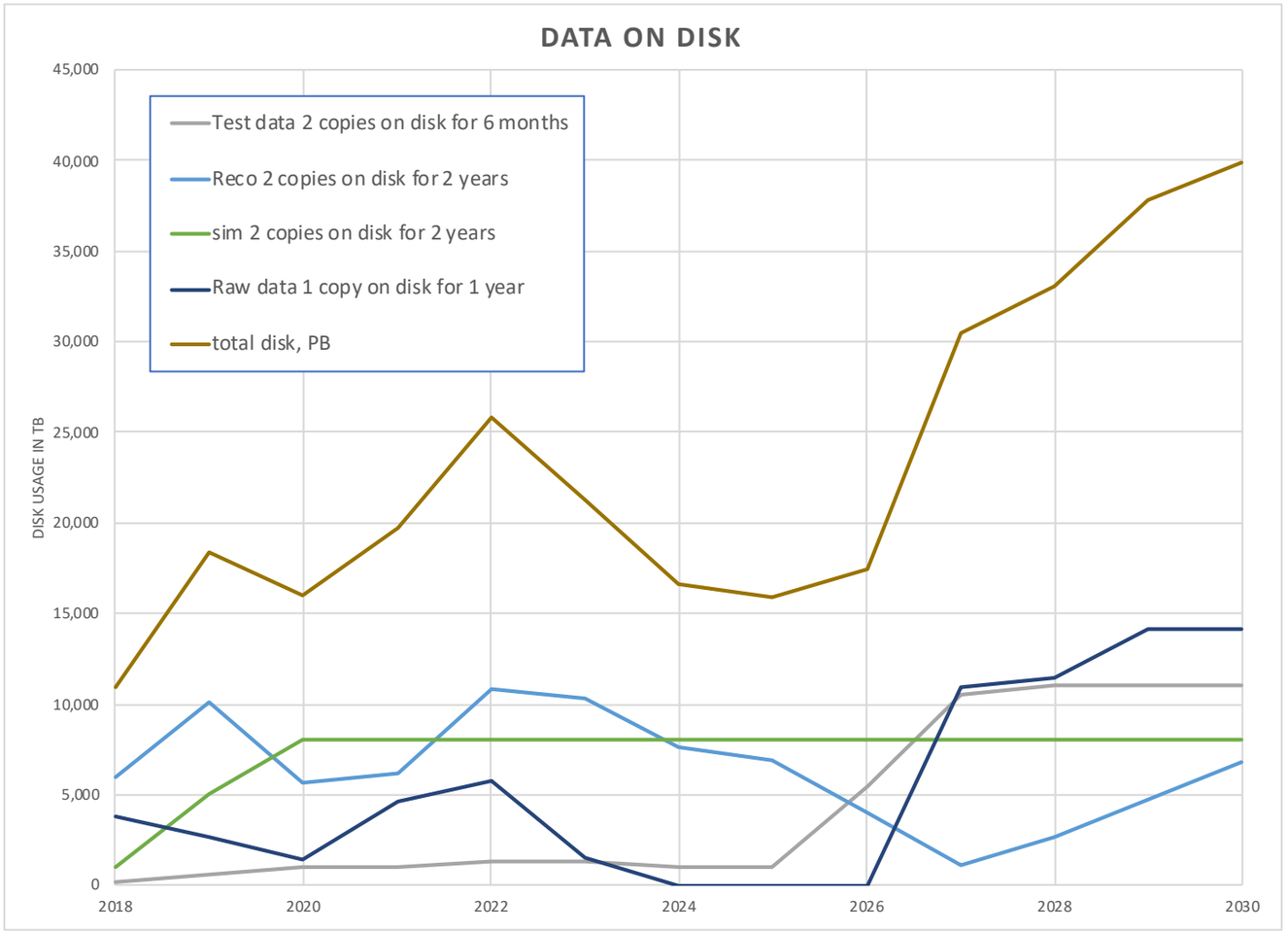
Summary

- Proposed resources needs for 2020 - 2022 were reviewed by Fermilab CRSG
- estimates based upon experience from ProtoDUNE, FD TDR, and ND CDR development
- tape and disk estimates may be the largest driver of dedicated resources
- CPU needs on the WLCG/ OSG are being met currently



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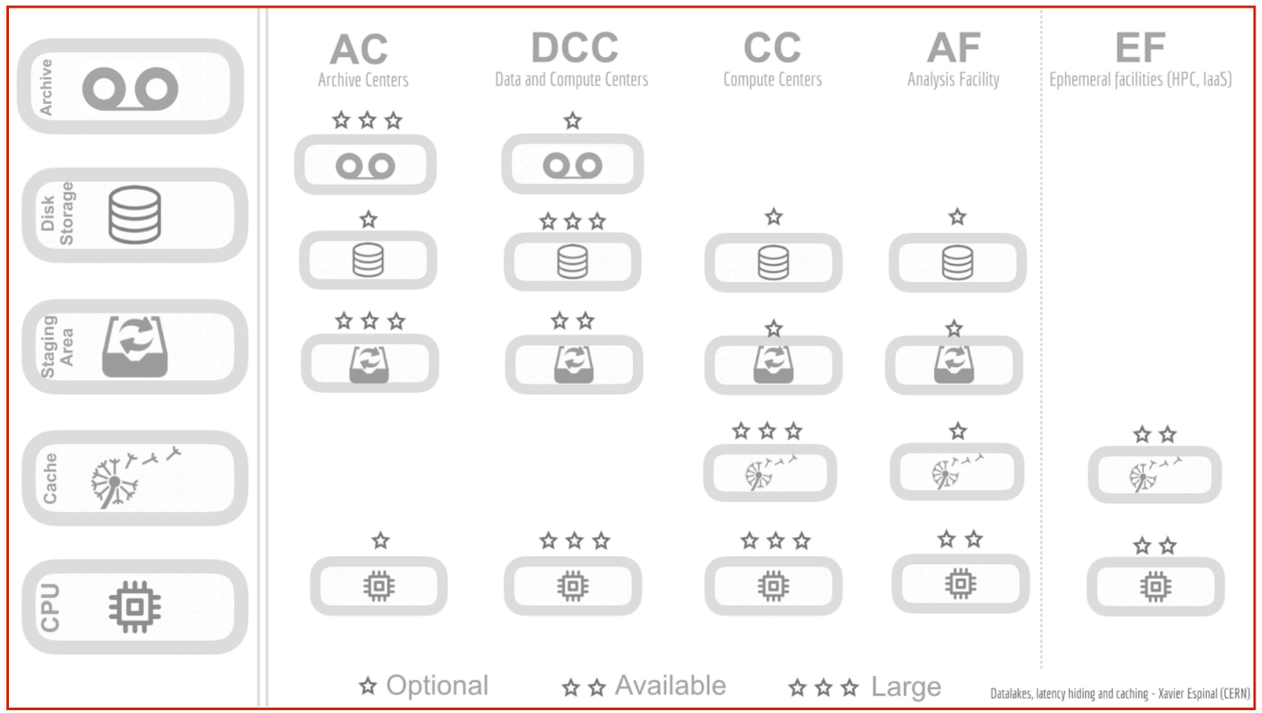
Discussion

DUNE Computing Model for Institutional Sites

- Based the HSF DOMA model for sites
  - Archive Center (AC) - tape/staging
  - Data and Compute Center - disk + CPU
  - Computer Center (CC) - CPU + cache
  - Analysis Facility (AF) - cpu + cache
  - Ephemeral Facilities (EF) - (HPC, IaaS)
- Goal is to have resource split between FNAL and other institutions - 25%/75%
- FNAL has some custodial responsibilities from the Dept of Energy that make this not possible for tape



Data Access in DOMA, HSF/OSG/WLCG Joint Workshop J-LAB Newport News, VA 19-23 March 2019

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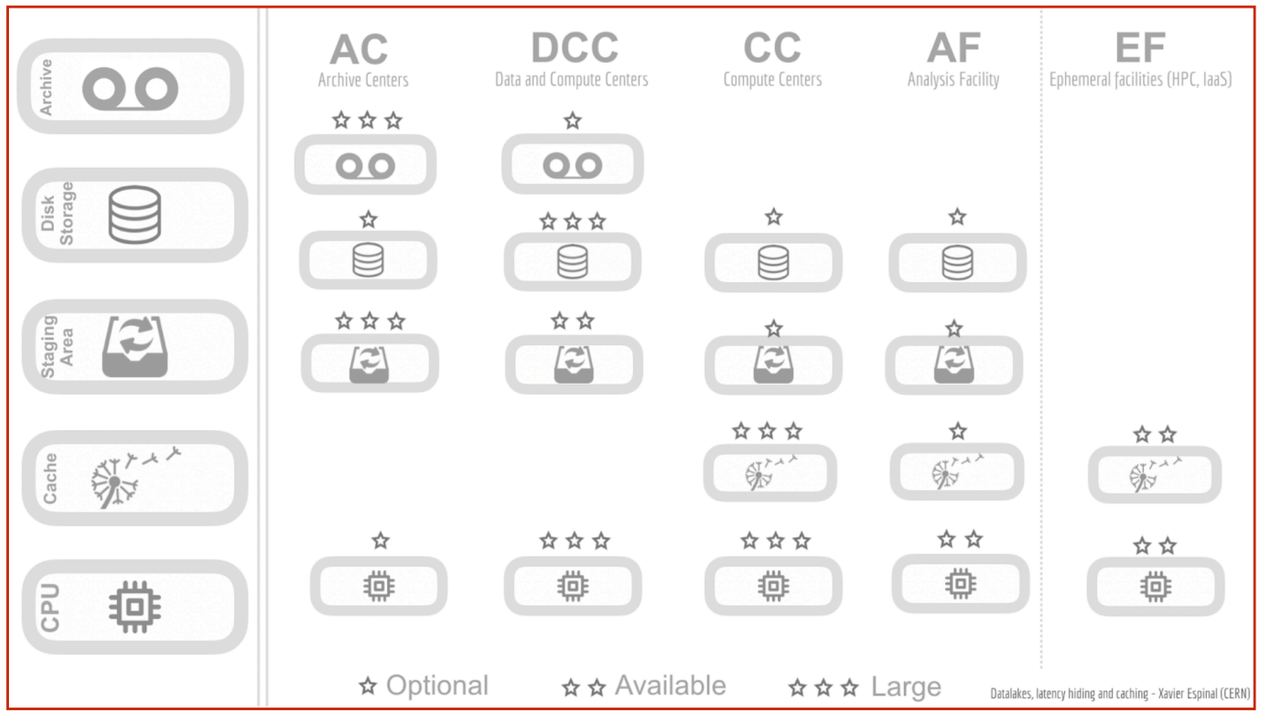
DUNE Computing Model for Institutional Sites

- Simplified terms for current DUNE sites
  - Tape Site - tape/staging
  - Disk Site - disk + CPU
  - Compute Site - CPU + cache
  - Analysis Site - cpu + cache
  - HPC - (HPC, IaaS)
- Goal is to have resource split between FNAL and other institutions - 25%/75%
- FNAL has some custodial responsibilities from the Dept of Energy that make this not possible for tape



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