Status report on KEK CRC

Tomoaki Nakamura

on behalf of KEK Computing Research Center

Mission of KEK

KEK Tsukuba: SuperKEKB, PF, ATF
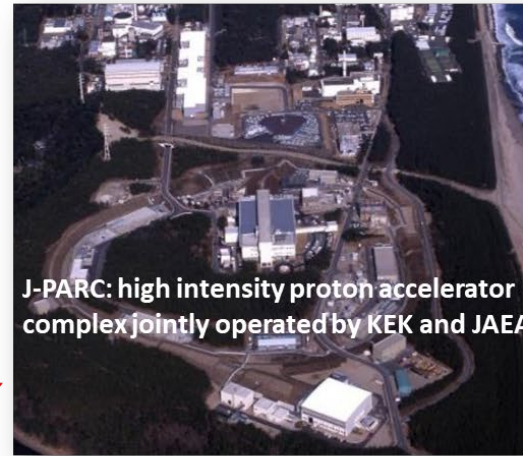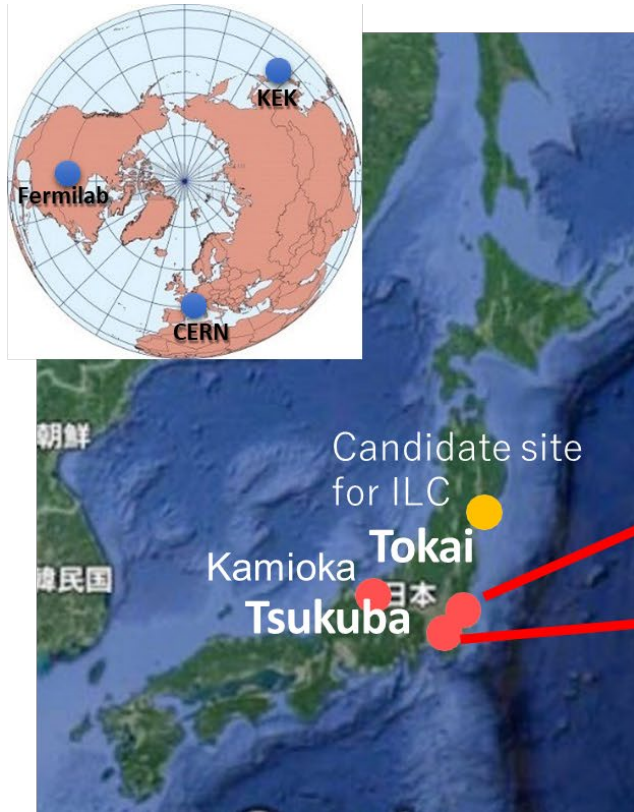
J-PARC: high intensity proton accelerator complex jointly operated by KEK and JAEA

KEK covers diverse field of accelerator based science making full use of the electron machines in Tsukuba and the proton machines in Tokai.

Muon g-2/EDM

Hyper-Kamiokande

COMET

J-PARC

- Hadron hall: Particle and nuclear physics experiments with fixed target.
- Neutrino facility: Neutrino beamline for T2K and upgrade program for Hyper-Kamiokande, COMET.
- MLF: Material and life science experiments with neutron and muon probes. Muon g-2/EDM experiment will be done at MLF.
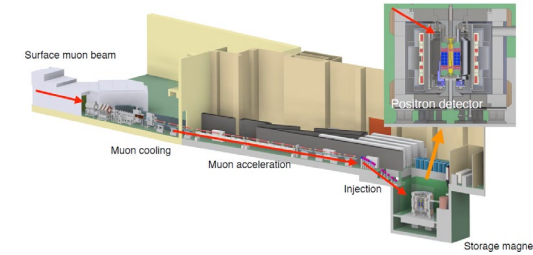
SuperKEKB/Belle II

- Asymmetric e+e- collider at Υ(4s) with target L=8x10^{35}/cm^2/s.
- ~10^{11} B, D and t measured with vertex reconstruction and PID.
- Physics run started March 2019.
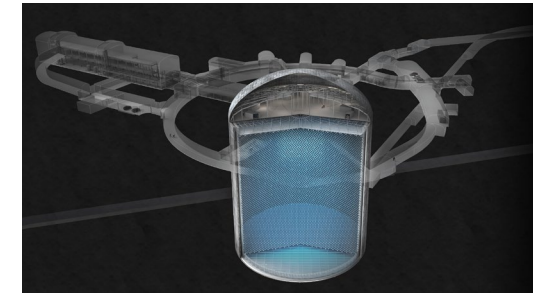- Belle II collaboration consists of 1000 physicists from 26 countries.

R&D

- ILC: Technical development and efforts to realize it
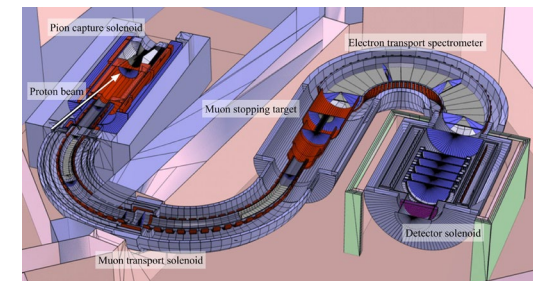- Contributions to HL-LHC and ATLAS upgrade
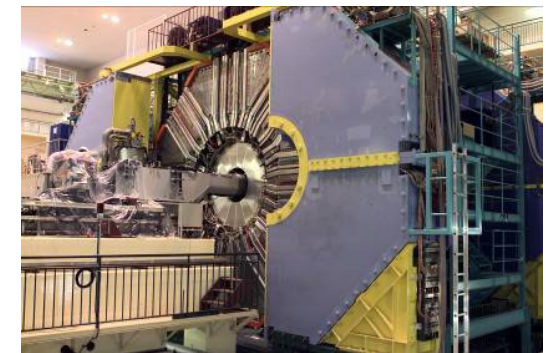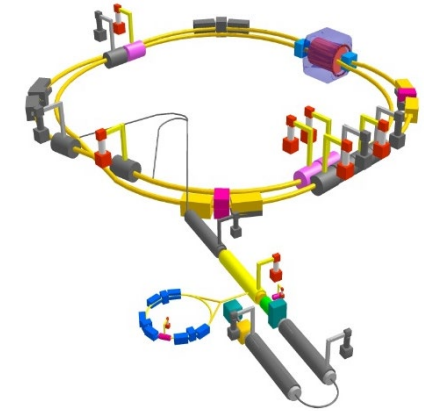
Supporting projects: France and Japan
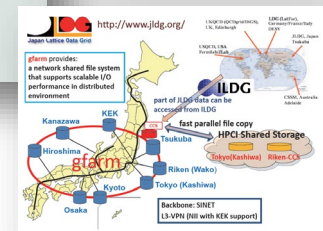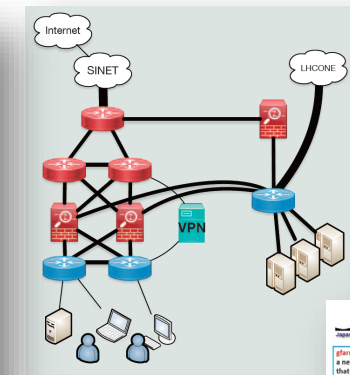

SuperKEKB/Belle II

The computing centers at CC-N2P3 and KEK-CRC support many high-energy experiments and cosmic ray experiments. Belle II, LHC (ATLAS, ALICE), and T2K are common projects supported by their respective computing centers, requiring coordinated use of computational resources.
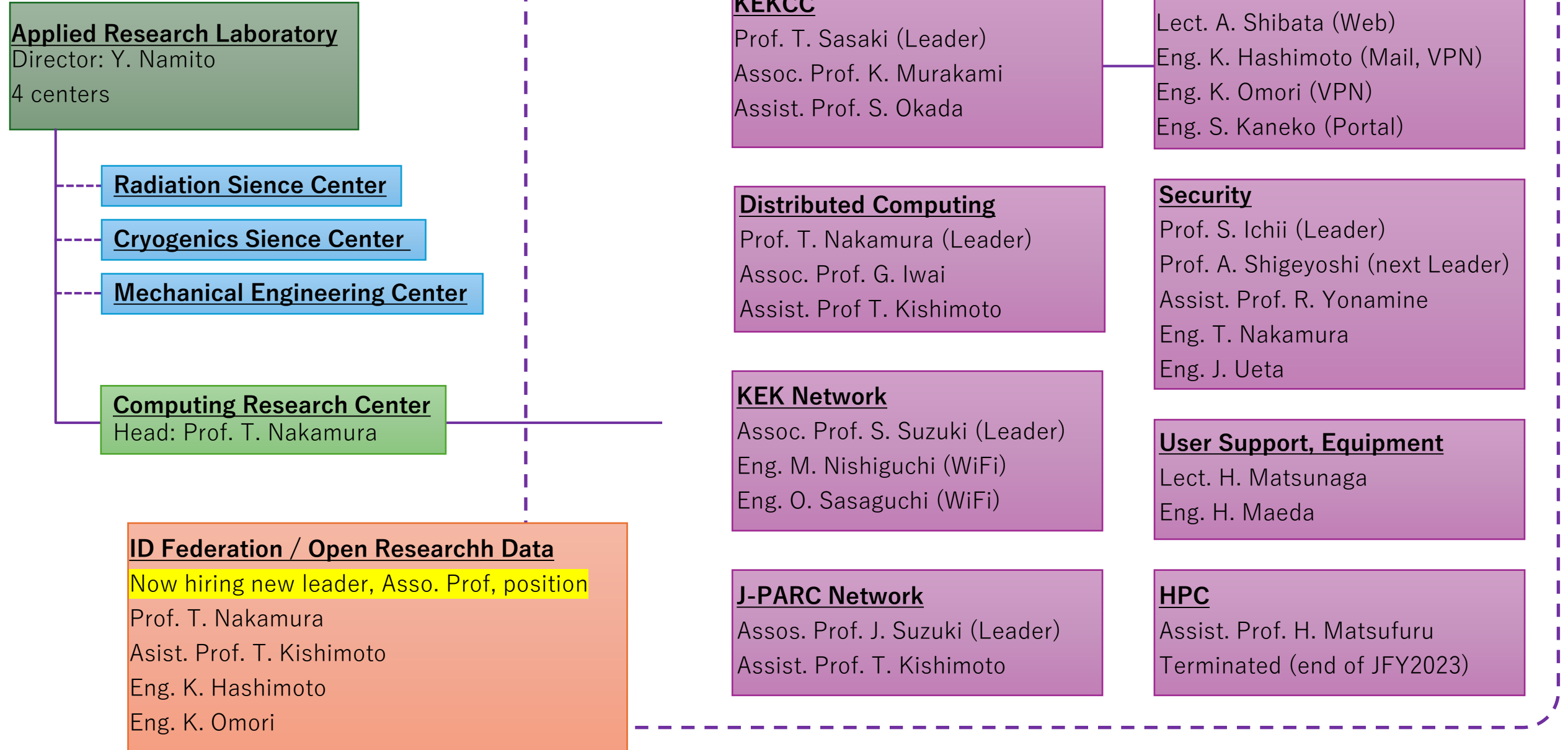
Computing Research Center (CRC)

The computing research center provides technical support in information and computing technology for various projects promoted by KEK. The activities contribute to all experiments utilizing high-energy accelerators by the research and development of IT systems. We deploy worldwide distributed computing systems and develop large-scale simulation software in collaboration with international research institutes. As computational science and technology experts, we try to make efforts in educational activities and human resource development, fostering collaboration and contributing to societal development.

- Member of CRC
  - Faculty: 14
  - Engineer: 8
  - Research fellow: 4
  - Technical and Office staff: 3
  - Support staff from companies: 1-4 for each system
- Sub-groups
  - KEK Central Computing System (KEKCC)
  - Distributed computing (Grid and Cloud)
  - Identity federation (Certificate authority, Open research data)
  - Networks (KEK-LAN, J-PARC LAN)
  - Basic IT Infrastructure (email, Web services)
  - Information security
  - User support
  - Facility maintenance
  - JLDG (data sharing for the lattice QCD simulation)
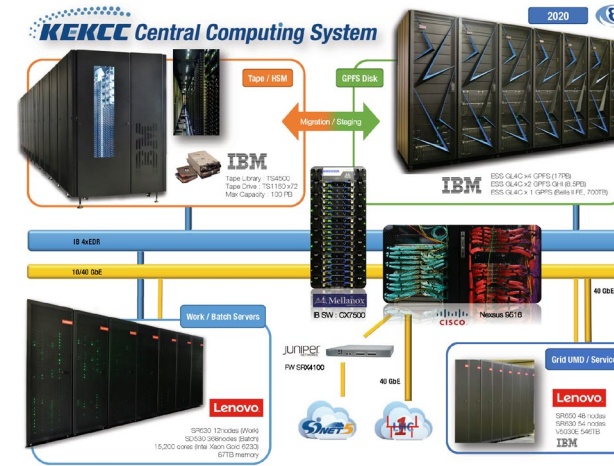 - Supercomputer (terminated the end of JFY2023)

CRC members

Applied Research Laboratory
Director: Y. Namito
4 centers

Radiation Sience Center

Cryogenics Sience Center

Mechanical Engineering Center

Computing Research Center
Head: Prof. T. Nakamura

ID Federation / Open Researchh Data
Now hiring new leader, Asso. Prof, position
Prof. T. Nakamura
Asist. Prof. T. Kishimoto
Eng. K. Hashimoto
Eng. K. Omori

KEKCC
Prof. T. Sasaki (Leader)
Assoc. Prof. K. Murakami
Assist. Prof. S. Okada

Basci IT infrastructure
Lect. A. Shibata (Web)
Eng. K. Hashimoto (Mail, VPN)
Eng. K. Omori (VPN)
Eng. S. Kaneko (Portal)

Distributed Computing
Prof. T. Nakamura (Leader)
Assoc. Prof. G. Iwai
Assist. Prof T. Kishimoto

Security
Prof. S. Ichii (Leader)
Prof. A. Shigeyoshi (next Leader)
Assist. Prof. R. Yonamine
Eng. T. Nakamura
Eng. J. Ueta

KEK Network
Assoc. Prof. S. Suzuki (Leader)
Eng. M. Nishiguchi (WiFi)
Eng. O. Sasaguchi (WiFi)

User Support, Equipment
Lect. H. Matsunaga
Eng. H. Maeda

J-PARC Network
Assos. Prof. J. Suzuki (Leader)
Assist. Prof. T. Kishimoto

HPC
Assist. Prof. H. Matsufuru
Terminated (end of JFY2023)

Central Computing System (KEKCC)

2024	2025	2026	2027	2028

KEKCC2020

KEKCC2024

KEKCC2028

Construction, Data migration, Stabilization

Specification, Procurement, Construction, Migration

Technology surveillance

- System Specification
  - KEKCC2020
    - CPU: 15,200 cores
    - Disk: 17 PB + 8.5 PB (HSM)
    - Tape: 100 PB（capacity）, 72 drives
  - KEKCC2024
    - CPU: 12,096 cores
      performance improvement: 170%/core, 140% in total
    - Disk: 20 PB + 10 PB (HSM)
    - Tape: 120 PB (capacity), 70 drives
- Status
  - Lack of resources: procured resources are insufficient for demand from experiments
  - Filled up all job slots regularly
  - 46PB of data is already archived in the tape library
- Research and Development
  - It is essential to constantly investigate available technologies for system renewal in every four years.
  - The state of the supply chain and fluctuations in exchange rates have made it challenging to keep a stable quantity of resources can be procured at a fixed budget.
  - Dominance: Hyperscaler, Disadvantage: Academic institutes

KEKCC2020
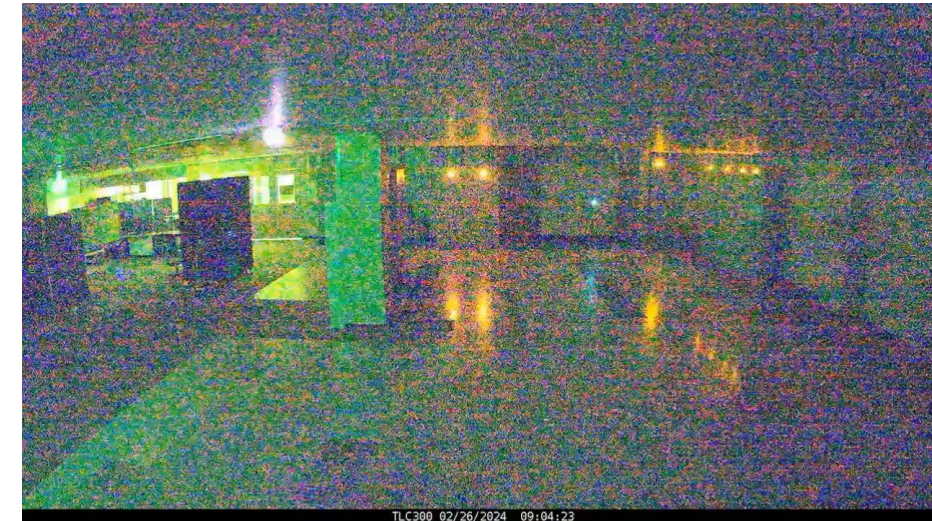
KEKCC2024

Jun. 3, 2024

Formulation of spec, Procurement, Construction, Data migration

Computer South bldg. KEKCC2024
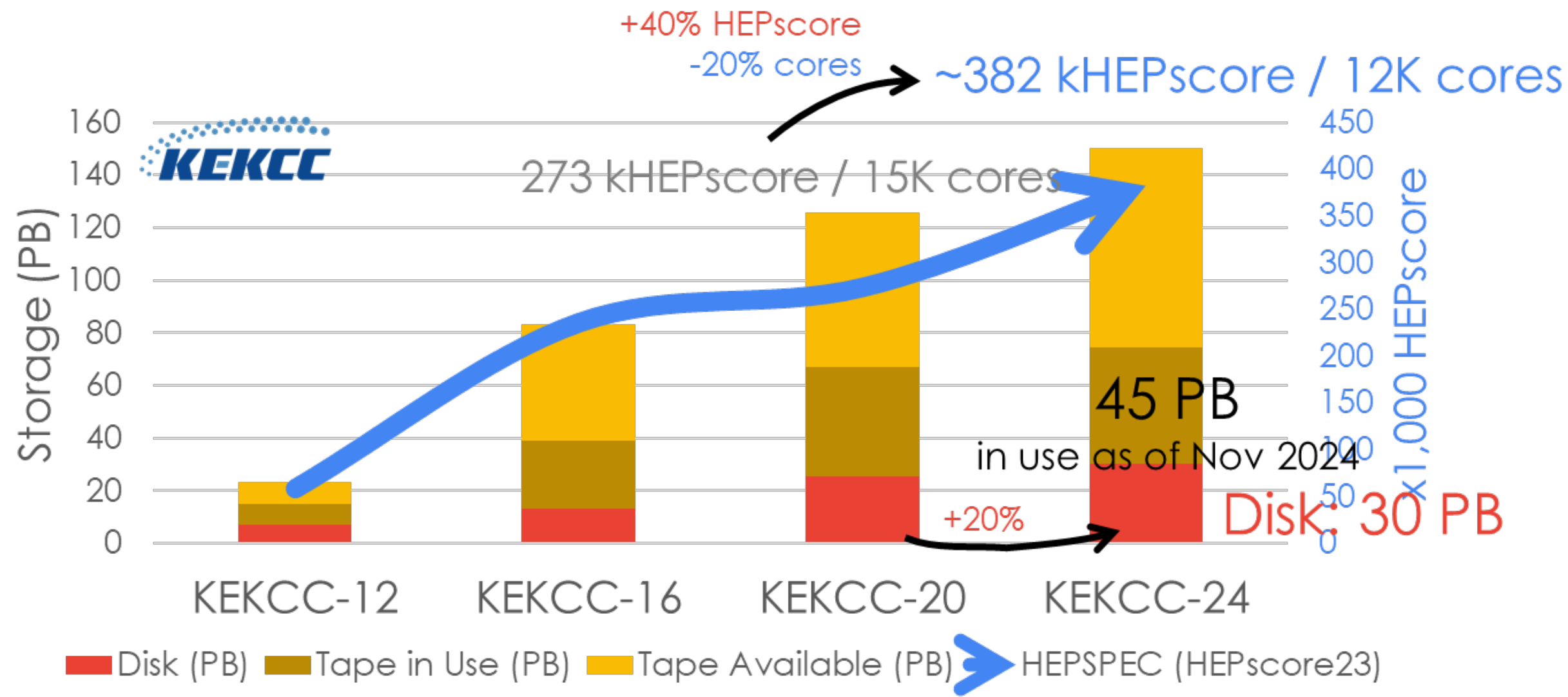

Computer North bldg. KEKCC2020

- Oct. 31, bit was opened successfully completed for KEKCC.
  - RFI: Feb. 2023, RFC: May. 2023, Tender Announcement: Aug. 2023
  - CPU: 15K cores -> 12K cores, but core performance is improved by more than 30 %
    - Intel Xeon Gold 6230 (40 cores/node) -> AMD EPYC 9654 (172 cores/node, 896GB memory)
  - Disk: 25.5 PB (17 + 8.5 HSM) -> 30 PB (20 + 10 HSM)
  - Tape capacity: 100 PB -> 120PB

Specification of KEKCC (Comparison with the previous system)

	KEKCC-2020	KEKCC-2024	Upgrade Factor
CPU Server	Lenovo SD530	Lenovo SR645v3	
CPU	Xeon Gold 6230 (20cx2/node)	AMD EPYC 9654 (96cx2/node)	
CPU cores	14,720 + 480 (work server)	12,096 + 512 (work server)	-20%
HEPscore23	273K	382K	+40%
OS	CentOS 7	RedHat EL9	
IB interconnect	Mellanox 4xEDR	Mellanox HDR100	
Disk Storage	IBM Elastic Storage System	IBM Elastic Storage System	
Disk Capacity	25.5 PB (8.5 PB for HSM)	30 PB (10 PB for HSM)	+20%
Tape Drive	IBM TS1160 x72	IBM TS1160 x70	
Tape Speed	20TB/vol, 400 MB/s	20TB/vol, 400 MB/s	
Tape max capacity	100 PB	120 PB	+20%

KEKCC: Site sale

+40% HEPscore
-20% cores → ~382 kHEPscore / 12K cores

273 kHEPscore / 15K cores

45 PB
in use as of Nov 2024

+20%

Disk: 30 PB

Storage (PB) — 160, 140, 120, 100, 80, 60, 40, 20, 0

×1,000 HEPscore — 450, 400, 350, 300, 250, 200, 150, 100, 50, 0

KEKCC-12 KEKCC-16 KEKCC-20 KEKCC-24

Disk (PB) Tape in Use (PB) Tape Available (PB) HEPSPEC (HEPscore23)

KEKCC: CPU usage/Utilization

x2 jobs and +10% CPU times greater than KEKCC-16)
Nearly 70% utilisation in average

- 10% for Grid mainly Belle II
- 50% for Belle and Belle II local batch jobs
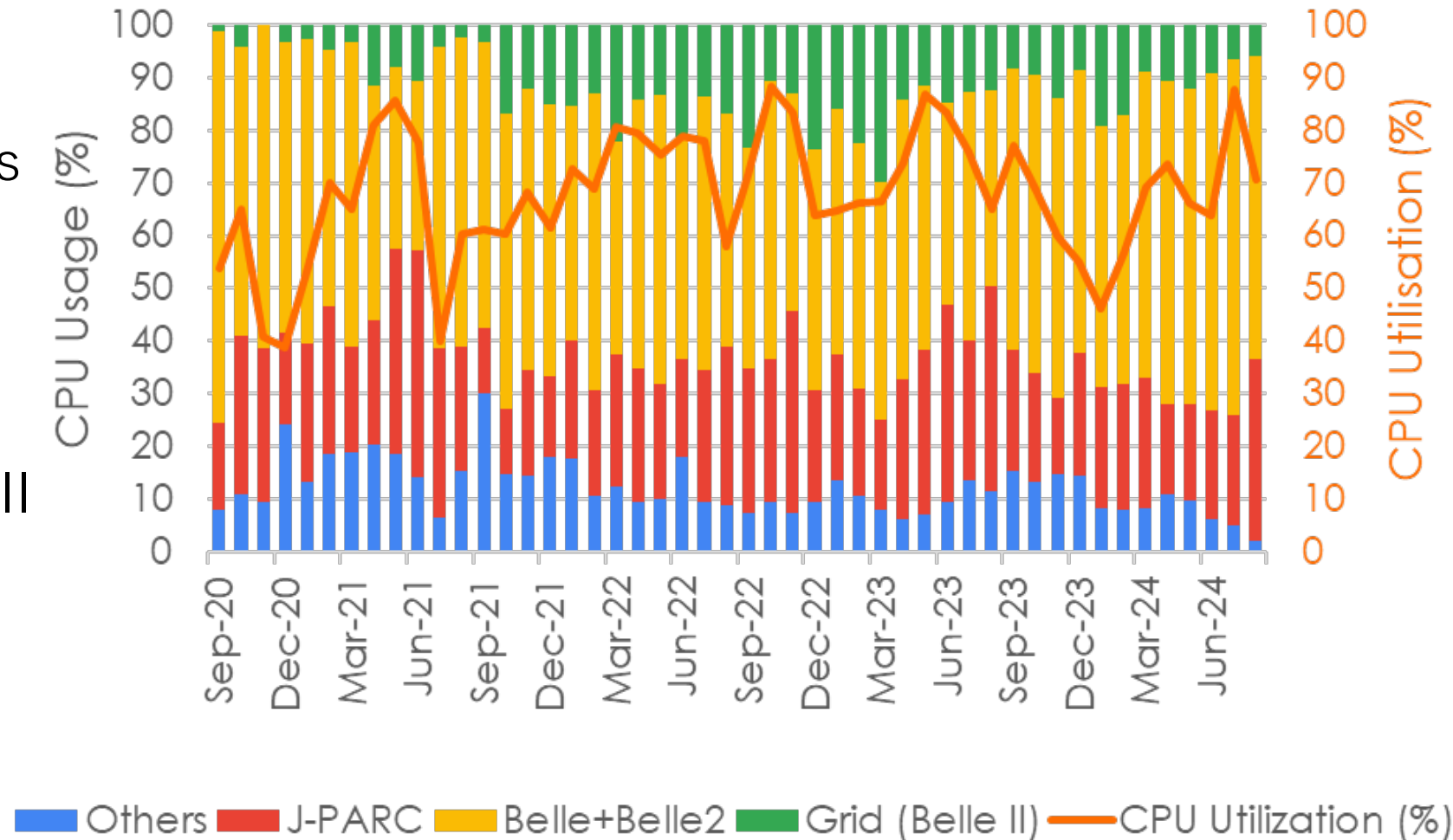
KEKCC: Storage usage

5 PB for Belle II
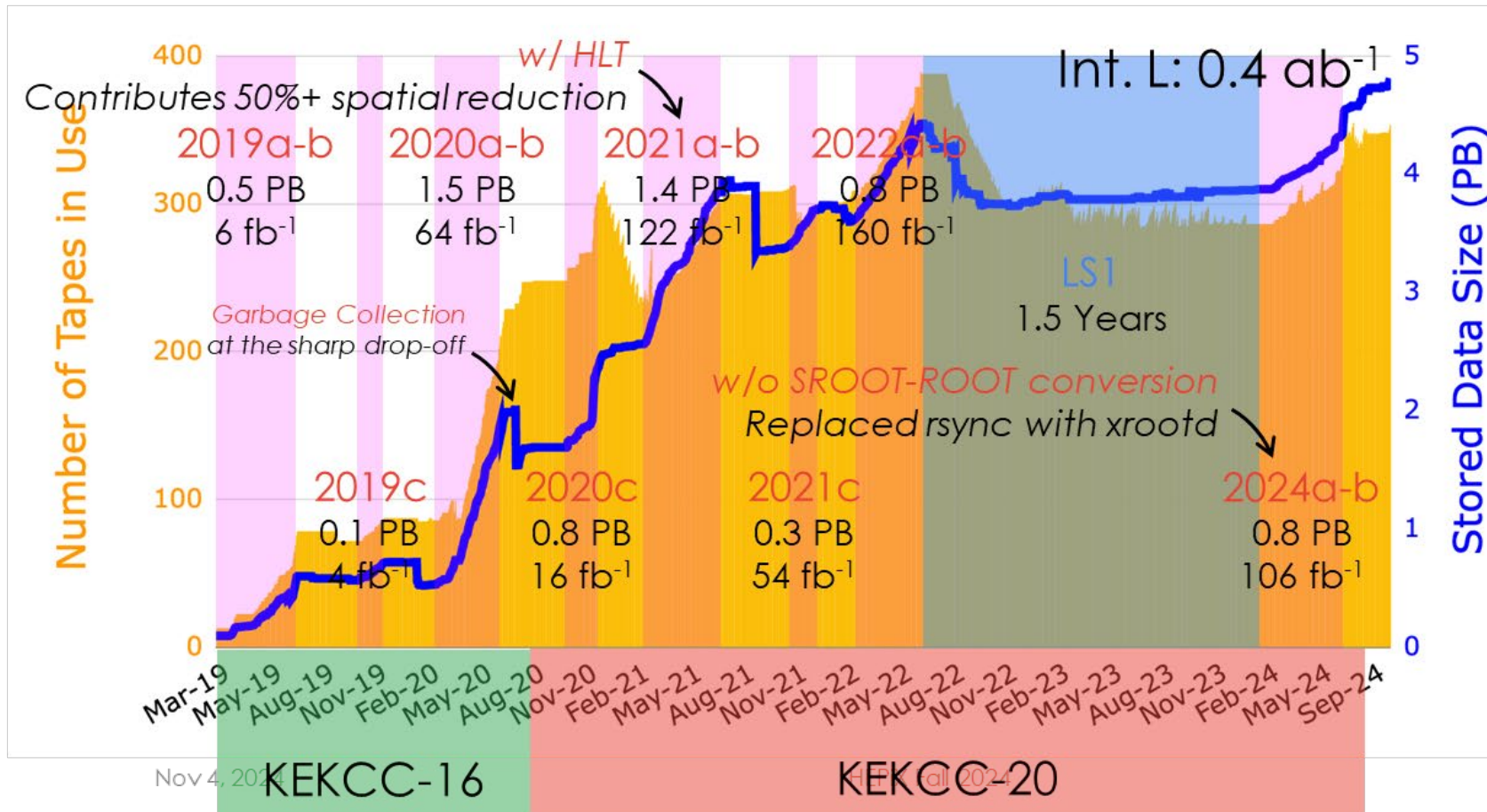6 PB for hadron experiment in J-PARC
18+ PB in KEKCC-16
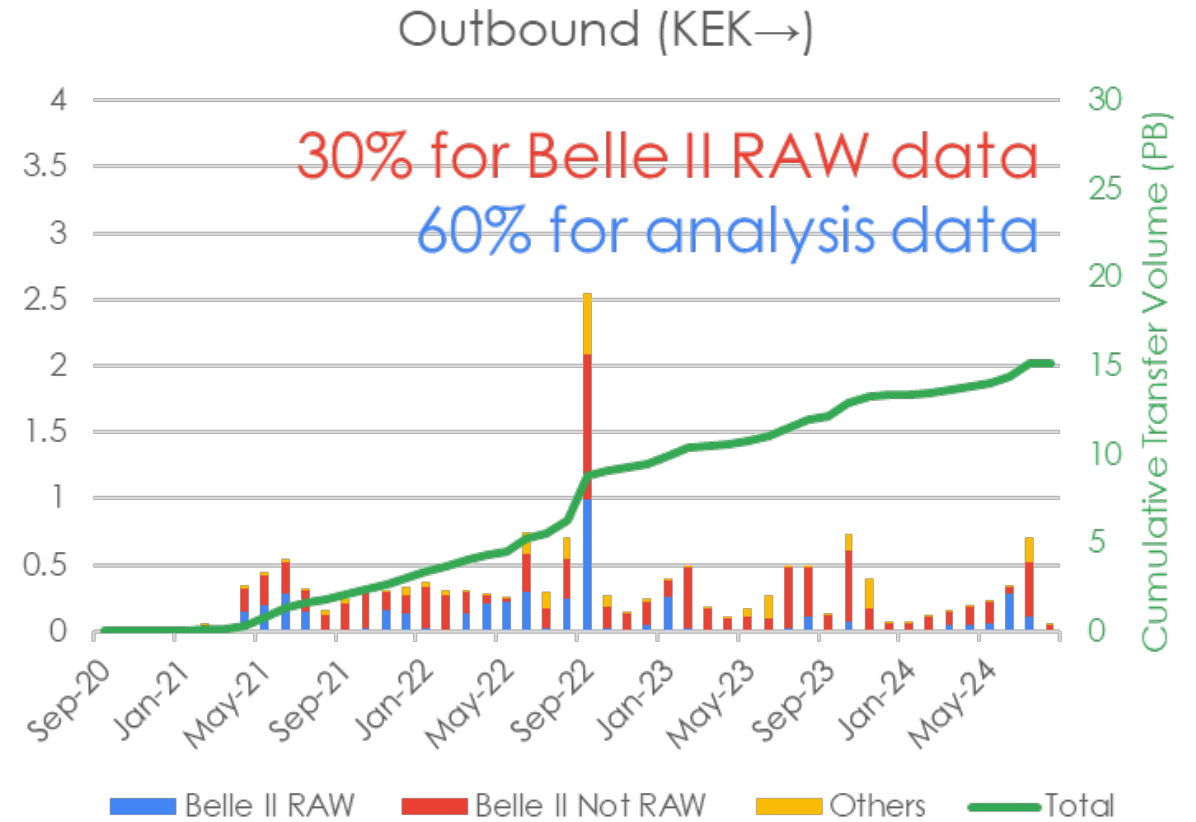   Mainly for Belle II MC production data
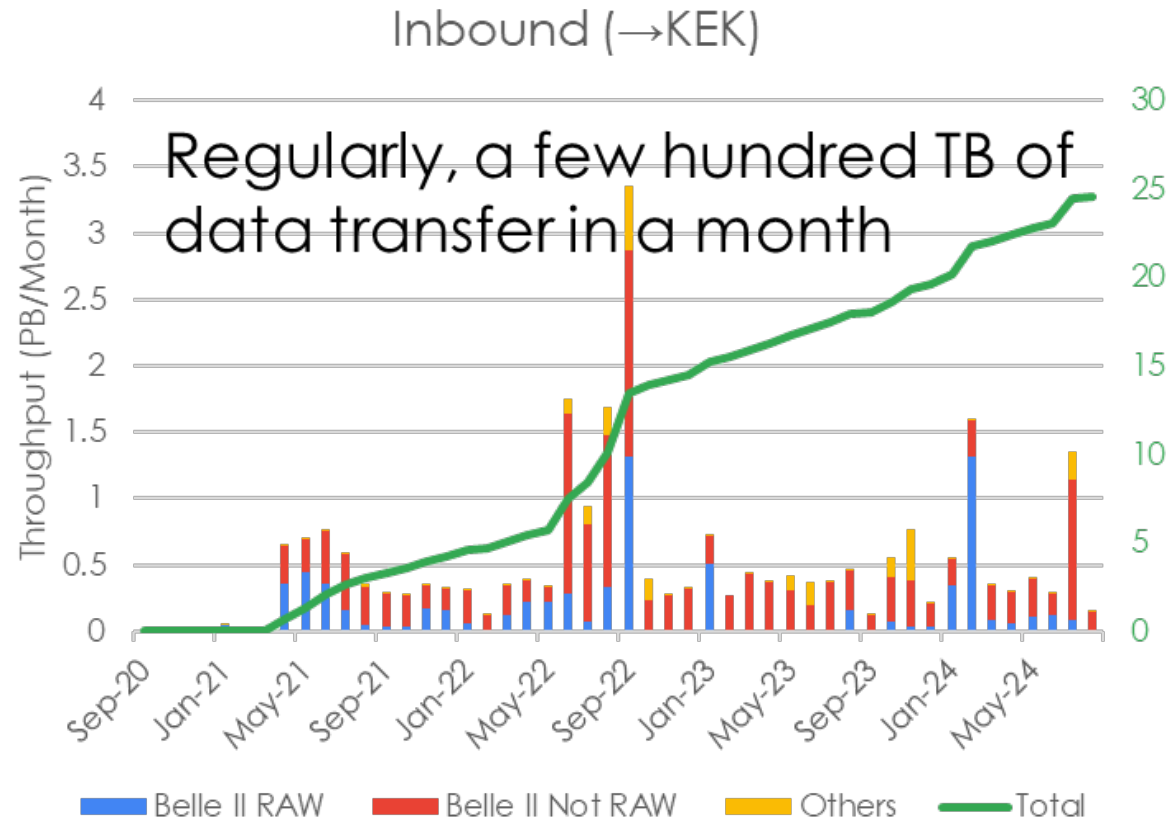   All data has been migrated
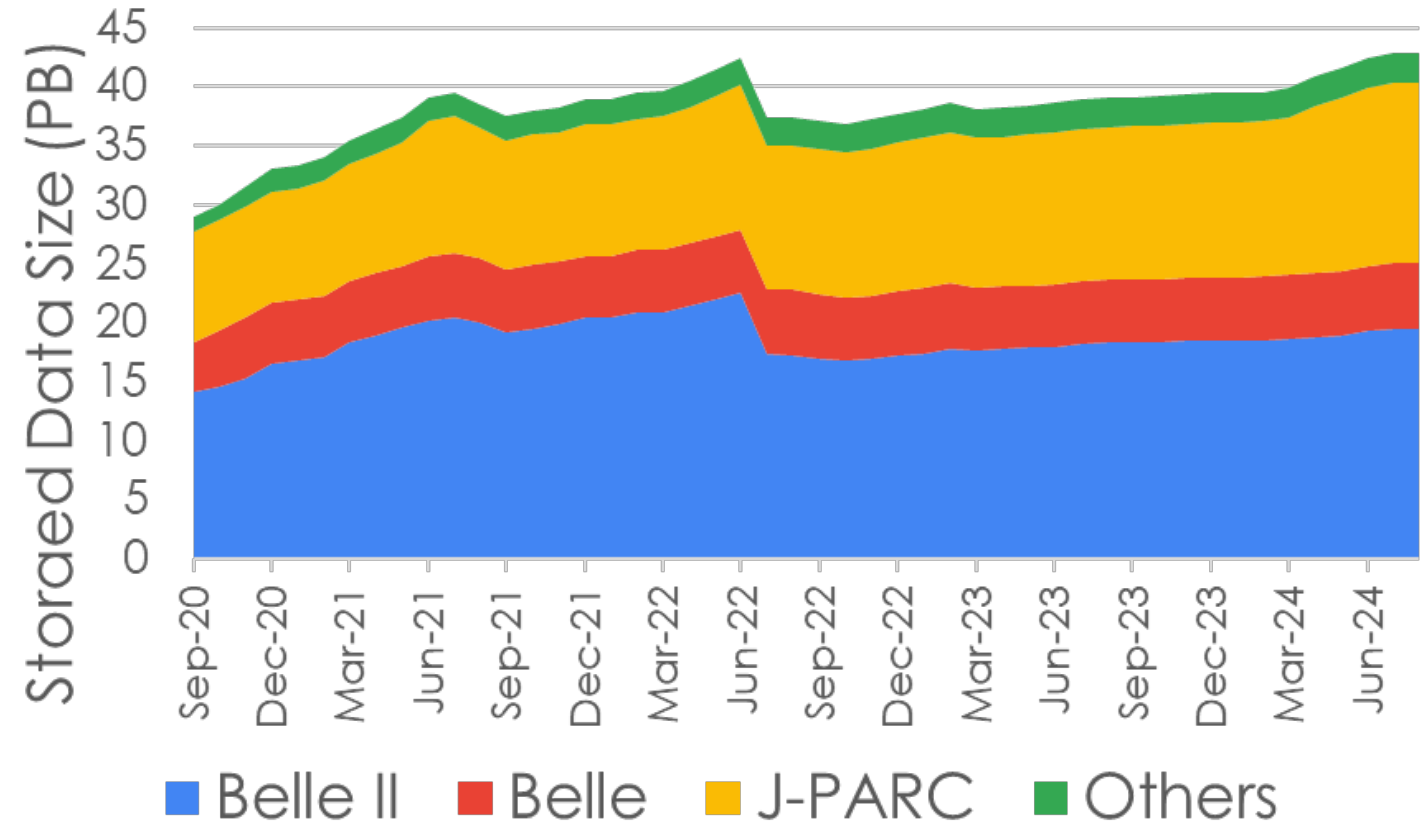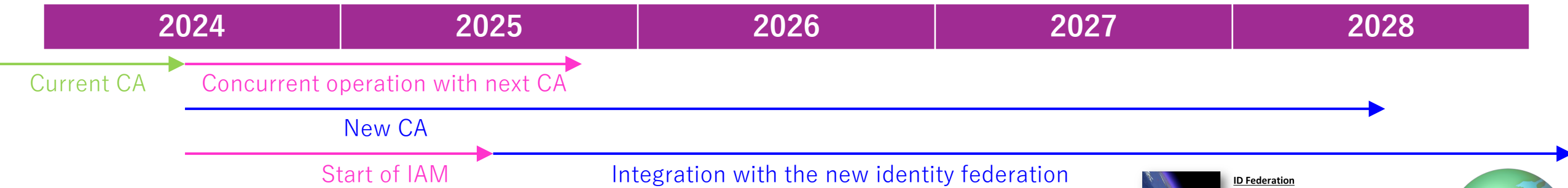
Belle II archived data and integrated luminosity

Belle II RAW data backup has been distributed for 6 raw centres: BNL, UVic, CNAF, DESY, KIT, and CCIN2P3
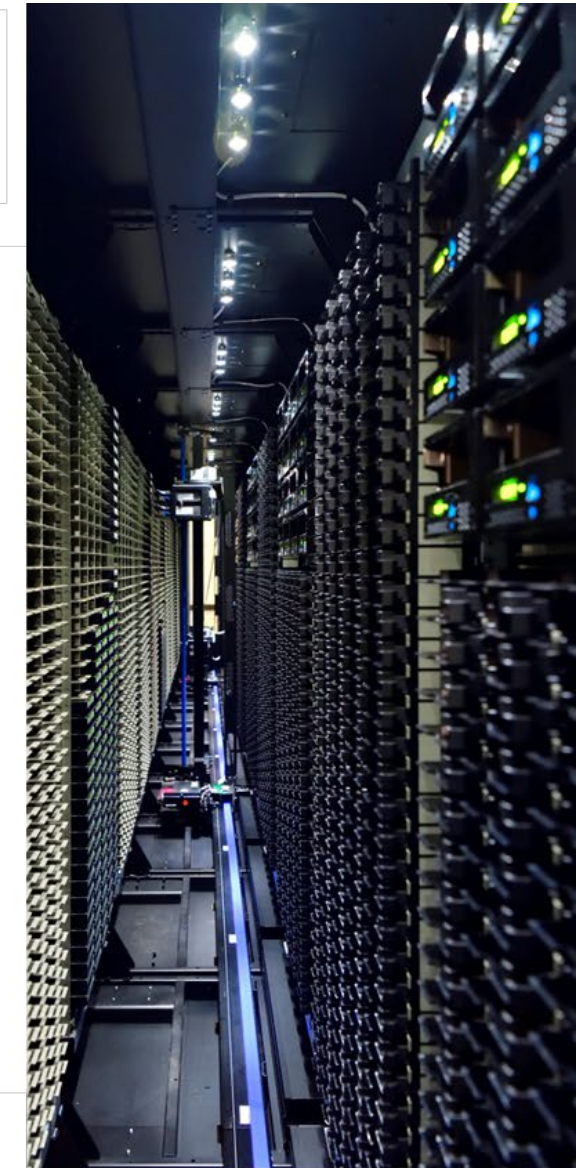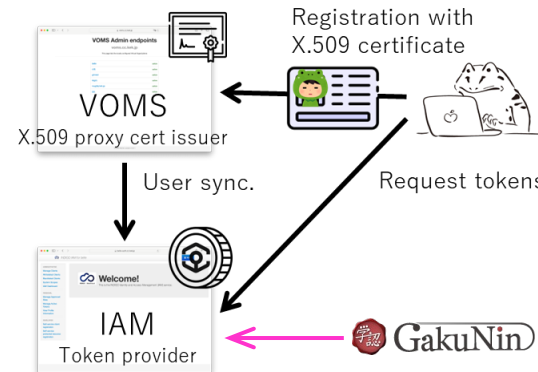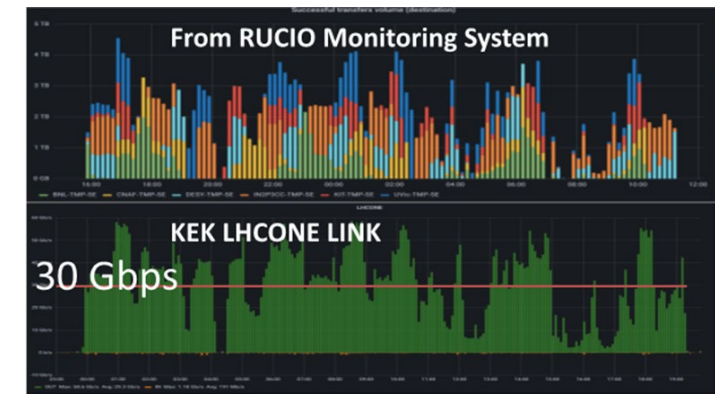
KEKCC: Data transfer volume

Tomoaki Nakamura
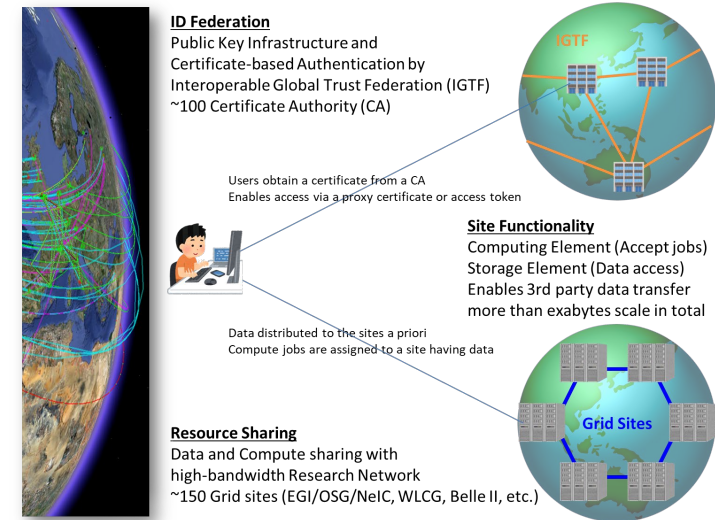
Distributed Computing and Identity federation

2024	2025	2026	2027	2028

Current CA

Concurrent operation with next CA

New CA

Start of IAM

Integration with the new identity federation

- Grid Certificate Authority (CA)
  - The KEK CA has been an IGTF accredited CA authority and has issued approximately 8,000 Grid certificates for various Japanese institutes and experiments since 2006. Supporting project: Belle II, ATLAS, ILC, J-PARC muon g-2/EDM, T2K, KAGRA, JLDG, etc.
  - The current CA will reach 20 years of operation by the end of November 2025. The issuance of new certificates will be discontinued, and the CA will be replaced with the new system.
- Grid Service
  - KEK Grid site is one of the certified sites of the European Grid Initiative (EGI).
  - KEK became an observer of the Worldwide LHC Computing Grid (WLCG) in 2015.
  - KEK provides some central services as a Tier-0 site of Belle II, in addition to services in the usual Grid sites.
- Research and Development
  - Transition to the new identity federation replacing Grid certificate authentication
  - Enabling resource access using IAM tokens instead of VOMS proxy certificates

ID Federation
Public Key Infrastructure and Certificate-based Authentication by Interoperable Global Trust Federation (IGTF) ~100 Certificate Authority (CA)

Users obtain a certificate from a CA
Enables access via a proxy certificate or access token

Site Functionality
Computing Element (Accept jobs)
Storage Element (Data access)
Enables 3rd party data transfer more than exabytes scale in total

Data distributed to the sites a priori
Compute jobs are assigned to a site having data

Resource Sharing
Data and Compute sharing with high-bandwidth Research Network
~150 Grid sites (EGI/OSG/NeIC, WLCG, Belle II, etc.)

IGTF

Grid Sites

VOMS
X.509 proxy cert issuer

User sync.

IAM
Token provider

Registration with X.509 certificate

Request tokens

GakuNin

VOMS proxy → IAM token

From RUCIO Monitoring System

KEK LHCONE LINK
30 Gbps

WLCG Data Challenge 24

Grid service status

as Belle II dedicated

Service		OS	VM/Bare metal	Ethernet	IPv6	HA		UPS
B	StoRM	RHEL7 + ELS	Bare metal	10GE	☑	☑		
	VOMS	RHEL7 + ELS	VM	10GE	☑	☑ SIOS LifeKeeper		☑
B	IAM	RHEL9	Bare metal	10GE	☑	☑		☑
B	AMGA	RHEL7 + ELS	Bare metal	10GE	☑	☑ SIOS LifeKeeper		☑
	Top BDII	RHEL9	VM	10GE	☑	☑		
	Site BDII	RHEL9	VM	10GE	☑	☑		☑
	FTS3	RHEL9	VM	10GE	☑	☑		☑
	ARC-CE	RHEL7 + ELS	Bare metal	10GE	☑	☑		
B	CVMFS Stratum Zero	RHEL9	Bare metal	10GE	☑	☑		
B	CVMFS Stratum One	RHEL7 + ELS	Bare metal	10GE	☑	☑		
B	CVMFS publisher	RHEL9	VM	10GE	☑			
B	HTTP Proxy	RHEL9	VM	10GE	☑	☑		

Grid service availability

90% availability on average

Communication issues to AMS and/or LSF plugin in ARC

Service outages for the annual safety check of power facilities in the summer

Scheduled   Unscheduled   Availability
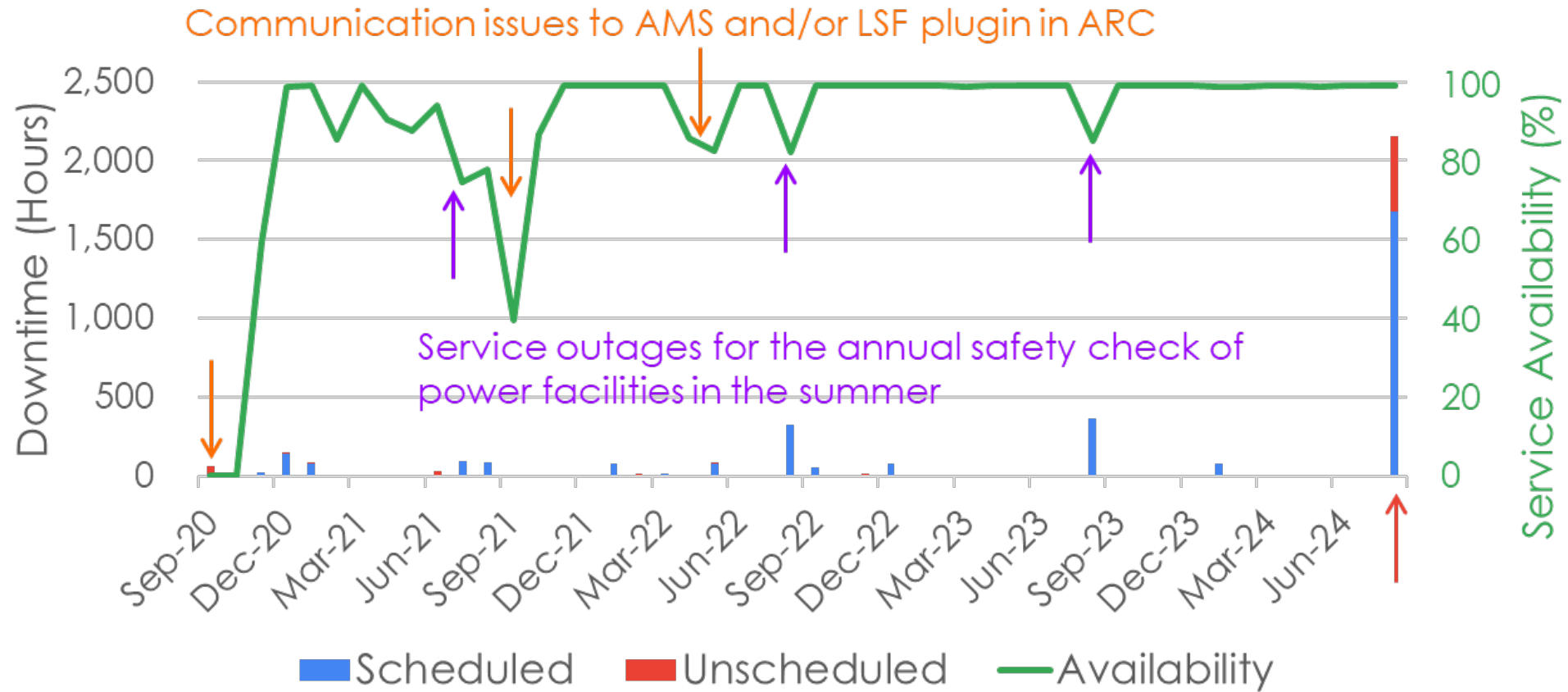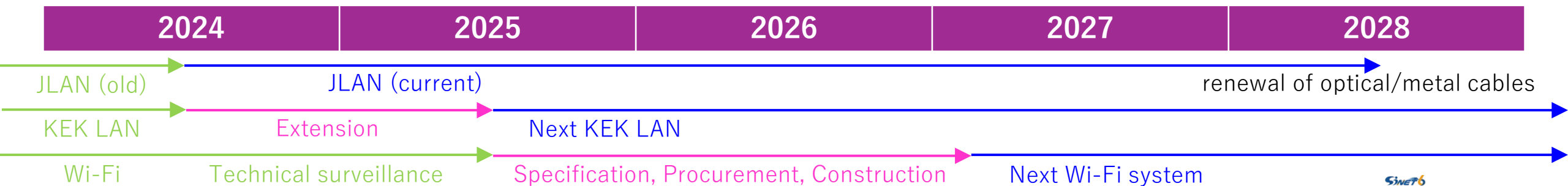
2K+ hours for migrating KEKCC-24

KEK Grid certificate authority
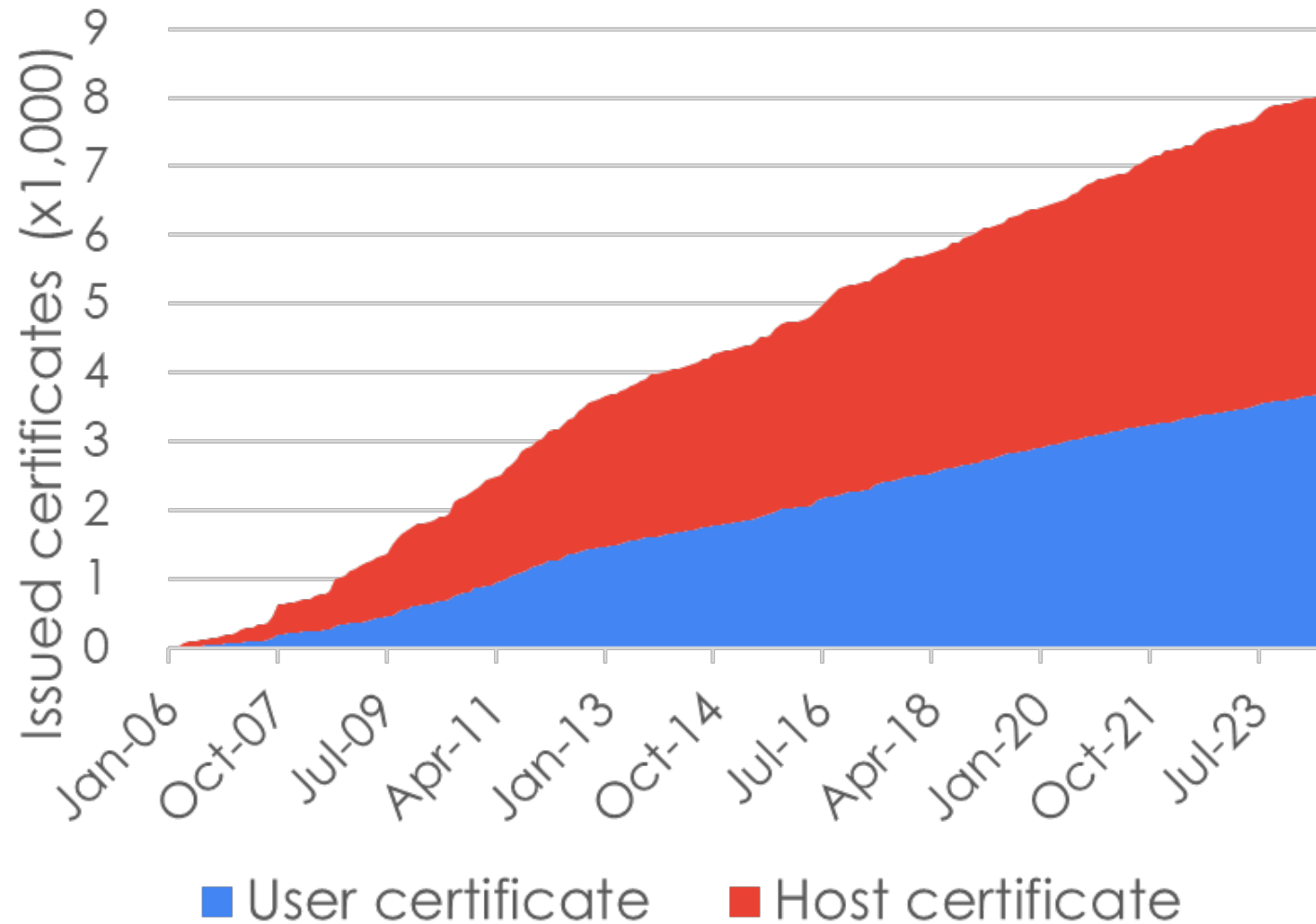
18 years operation

3.7K user certs

4.3K host certs

CA's root certificate will expire in November 2025
Expected to migrate from X.509 to OIDC token authorisation by the date – Unfortunately not!
Launching a new CA (KEK Grid CA 2024) and its root certificate with longer validity and a signature by a more secure algorithm, i.e.: SHA-2
    The current root certificate is signed by SHA-1, which NIST has disallowed 10+ years ago

Networks, KEK-LAN and J-PARC LAN

2024	2025	2026	2027	2028

JLAN (old)   JLAN (current)   renewal of optical/metal cables

KEK LAN   Extension   Next KEK LAN

Wi-Fi   Technical surveillance   Specification, Procurement, Construction   Next Wi-Fi system

- **KEK-LAN**
  - Approximately 7,300 devices connected at the Tsukuba Campus
  - External connection to SINET (Japanese NREN) is 100+10 Gbps
  - KEK became the first site other than the LHC experiments to connect to the LHC Open Network Environment (LHCONE) since 2016.
  - The lease will be extended for one year from the summer of 2024, and the system renewal to the next system will be carried out in August 2025.
  - The wireless LAN system was excluded from the KEK LAN procurement due to the rise in equipment prices, so it is necessary to consider their procurement.
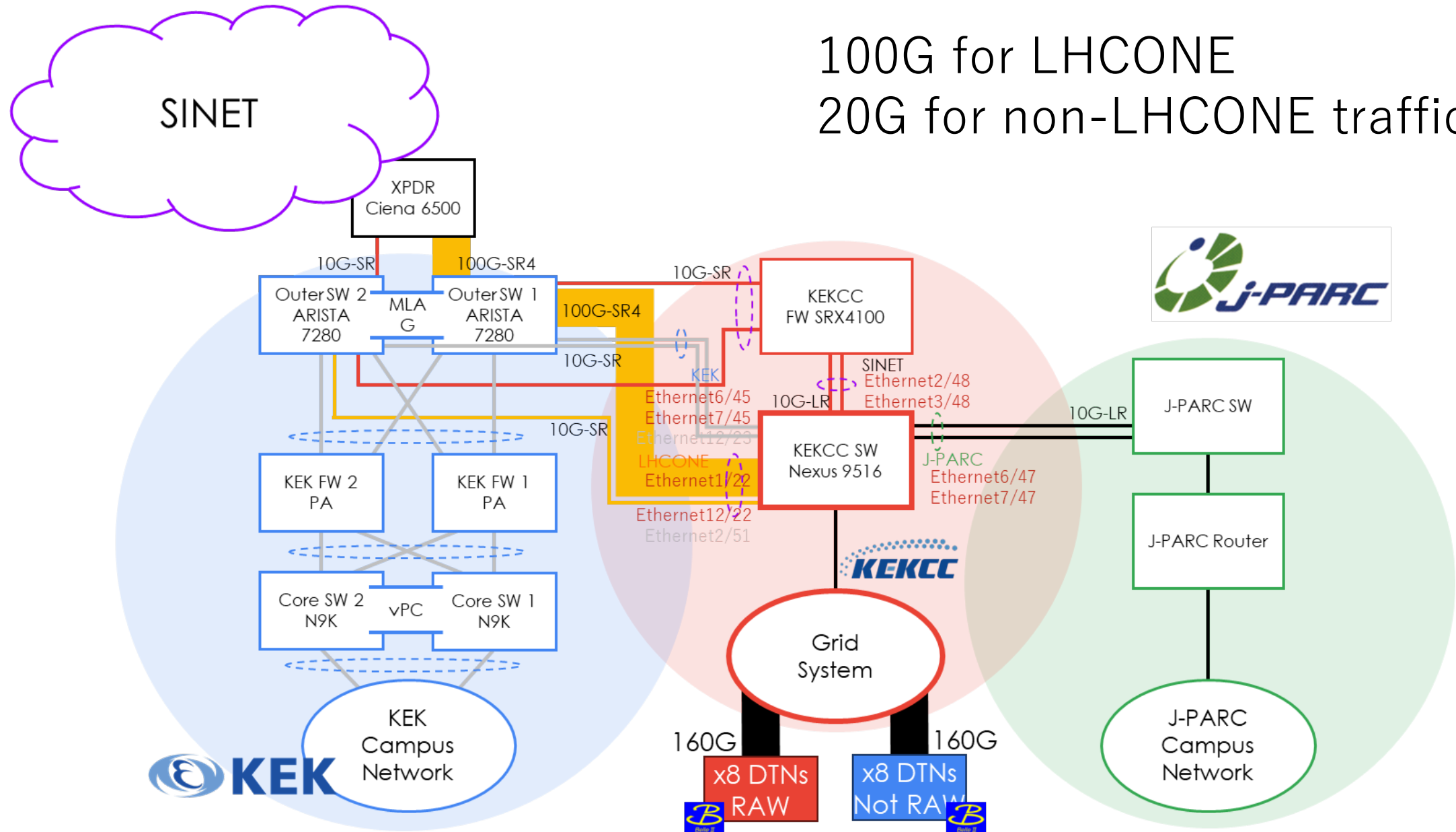
- **J-PARC LAN**
  - Approximately 5,800 devices are connected within the Tokai Campus
  - The Tsukuba-Tokai Campus connection is provided at a bandwidth of 20 Gbps via SINET L2VPN.
  - The Tokai-Kamioka connection is provided at a bandwidth of 10 Gbps to provide T2K timing information.
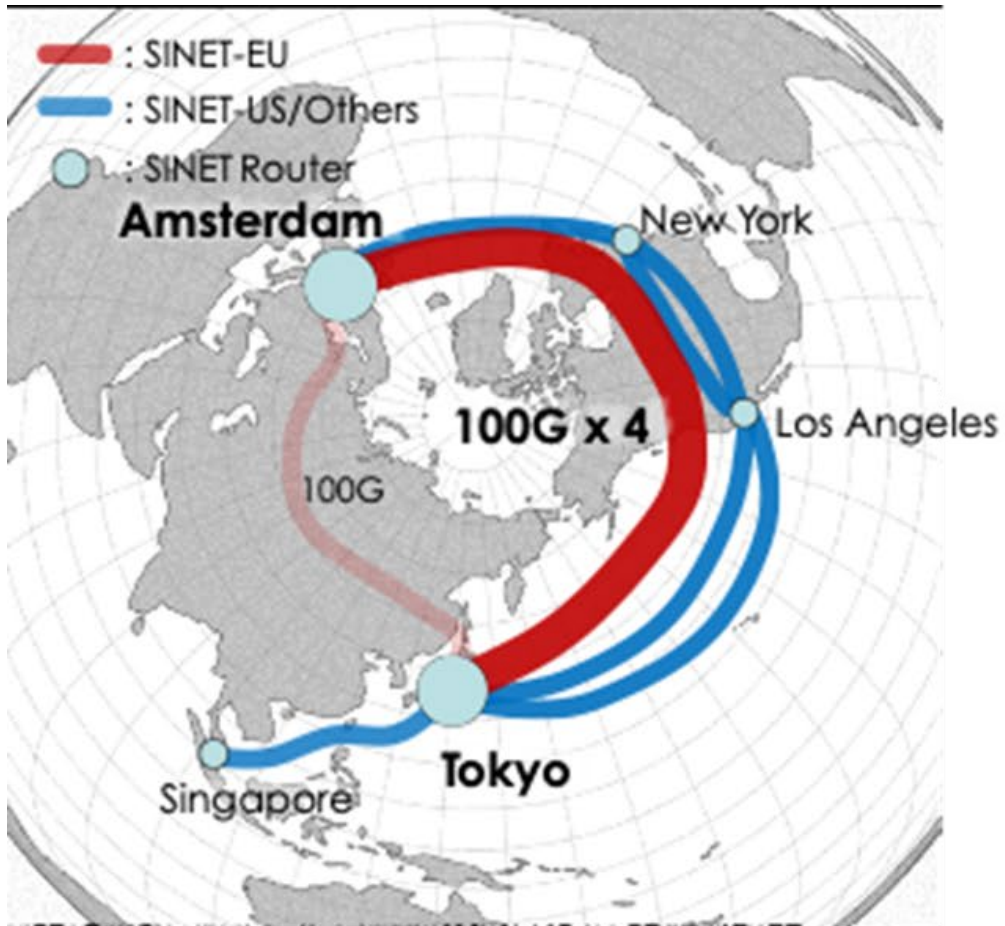 - The system was successfully migrated to the new system in summer 2024.
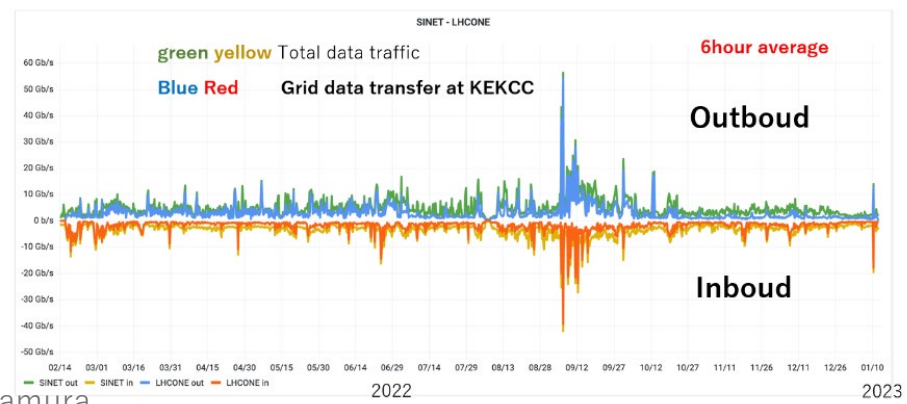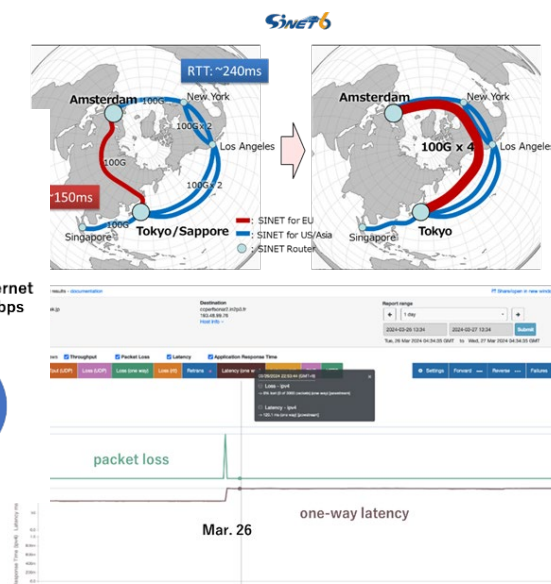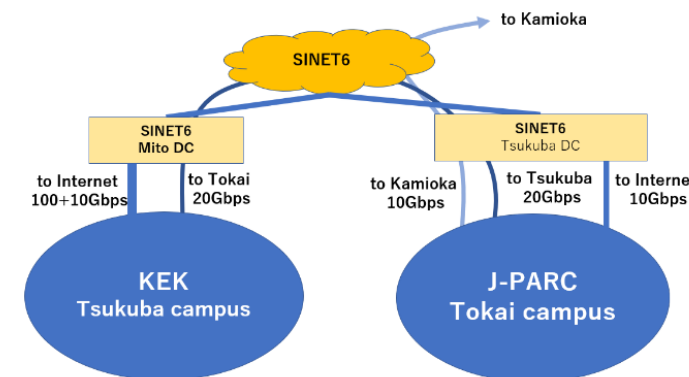
KEK internal network

International network connectivity


Siberian 100G route between Japan and Euro has been upgraded to the transatlantic route with 100G x4 lines
Dedicated line for the traffic between Japan and Euro, not shared with traffic for the US
To minimise the latency:
    traffic passes through fewer routers on the shortest route
    close to the Arctic

84 ms to 120 ms for CC-IN2P3, Lyon, Fr   +50% longer
Changed on 26th March
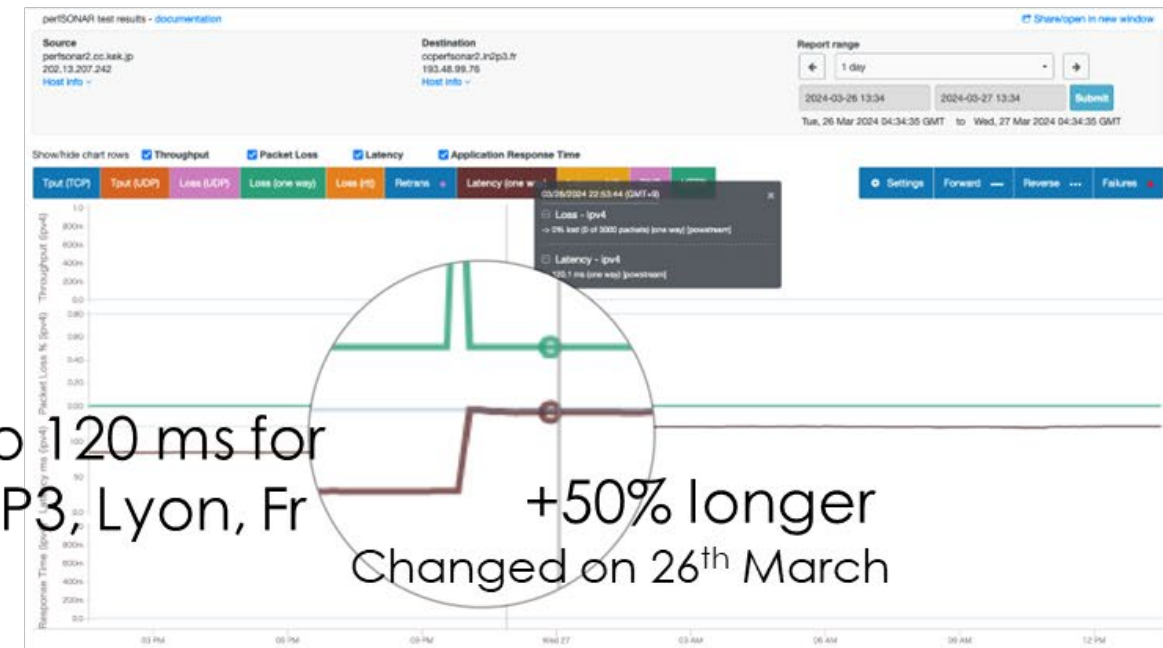
WLCG data challenge 24
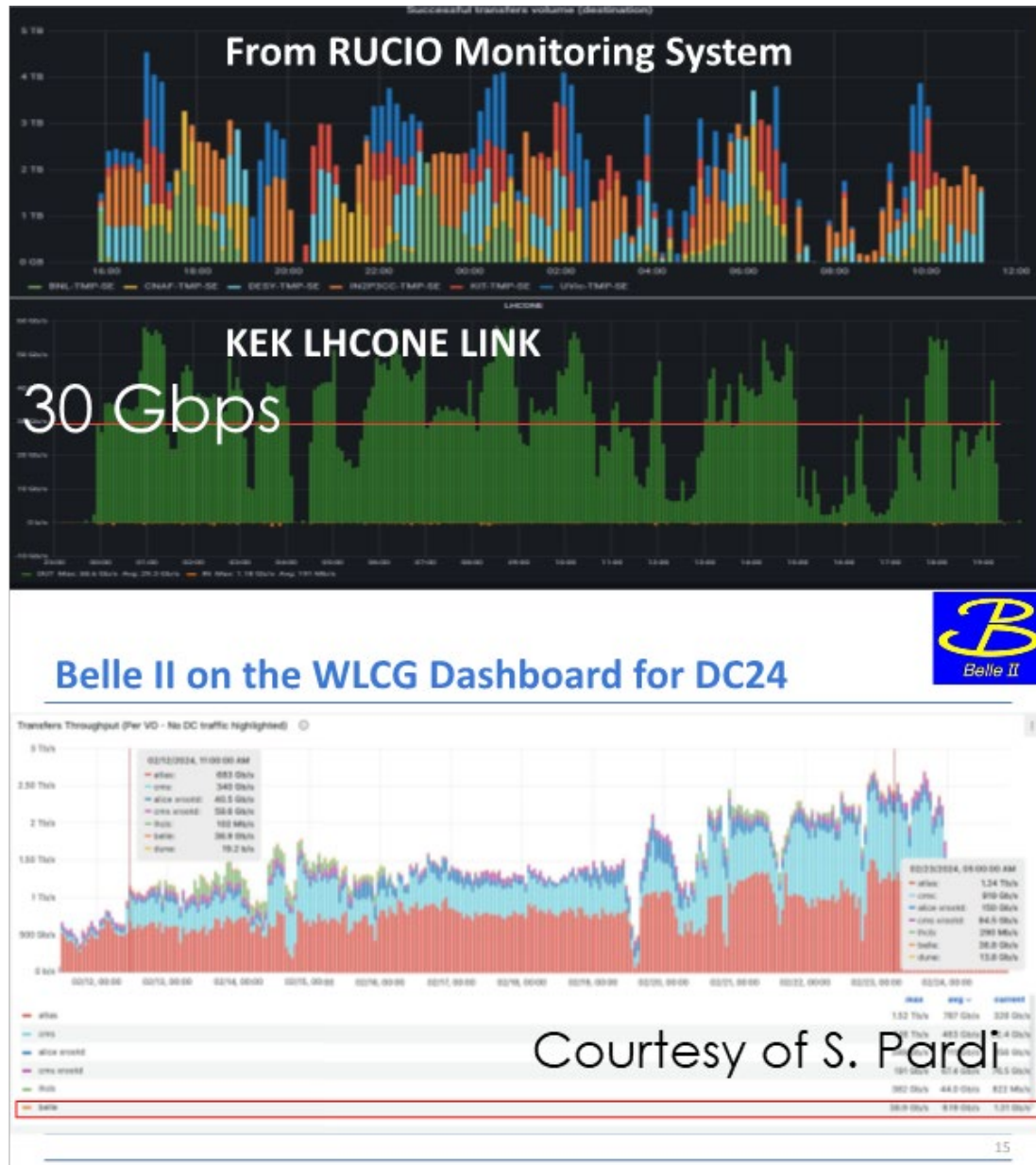
WLCG Data Challenge aims to demonstrate readiness for expected HL-LHC data rates, coordinated by WLCG

Belle II DC24: Raw data replication from KEK to Belle II RAW data centres:
    BNL, UVic, CNAF, DESY, KIT, and CC-IN2P3
260 TB / 50K files of pseudo-RAW data have been transferred in 20 hours at an average of 30 Gbps from KEK to RDCs
    Belle II HL scenario: 40 TB /day (3.7 Gbps)
Transfer protocol: Only HTTPS protocol in use, no GridFTP any more
    This is a mandated step for migrating to OIDC
Most of network traffic load among RDCs is via IPv6

Basic IT Infrastructure and Security

2024	2025	2026	2027	2028

KEKCC2020 → KEKCC2024 → KEKCC2028

KEK LAN → Extension → Next KEK LAN

Mail (on-premises) → Mail (concurrent operation, on-premises and Cloud) → Cloud mail

VPN extension

Renewal of IDS
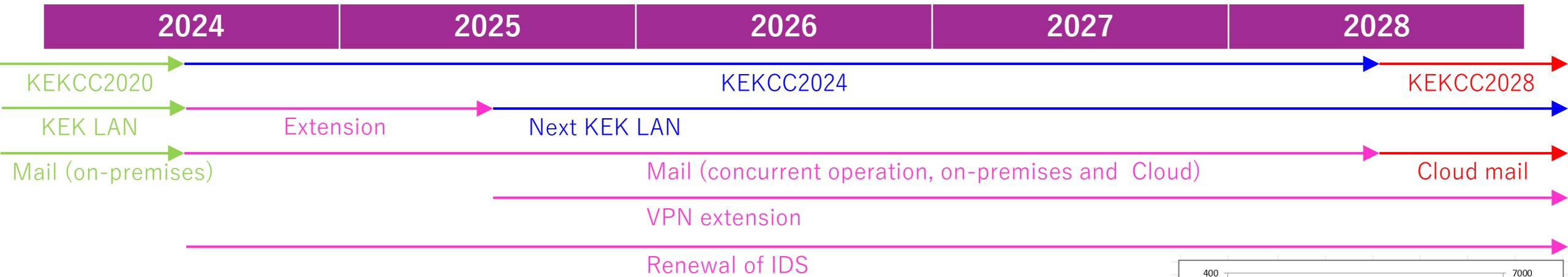
- Basic IT Infrastructure
  - Moving to a cloud-based email system
    - Migrate to cloud services by the end of the current KEKCC operational period (Aug. 2028).
  - Web services (updated with KEKCC renewal)
    - KDS, Conference web/Indico
    - KEK wiki
    - KEK cloud (online storage)
  - Wireless network for users
    - eduroam
    - Guest net
    - KEK Spot
    - VPN
  - User Support
    - Support desk
   - ccPortal (account request system)

- Information Security
  - KEK CSIRT
  - Monitoring by JSOC and NII SOC
  - Security equipment operation
  - Technical support for end users
  - Security training

- Information system section in J-PARC
  - Operation of J-PARC LAN
  - Maintenance and operation of J-PARC mail, Web, VPN
  - Information security of J-PARC

Number of Hosts, edge SW and wireless AP on JLAN
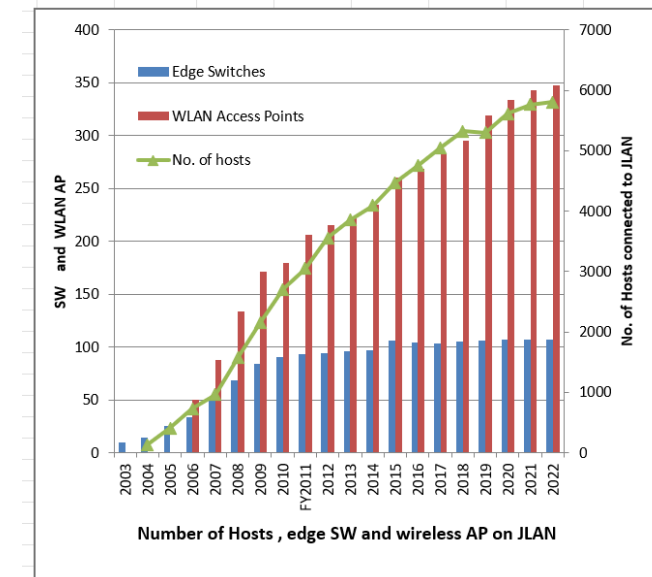
R&D, International collaboration, Education

- **Geant4:** toolkit for the simulation of the passage of particles through matter
  - Development and Maintenance of core software
  - Development of medical application
- **GRACE:** a system for perturbative, automatic numerical calculation of cross-sections of particle collision reactions on a computer
- Lattice QCD and Data sharing (JLDG)
- Simple deployment method of Grid middleware
- Optimization of large-scale computer systems by Deep Learning
- Exa-scale storage working group
  - Review and study of high-density, high-capacity tape technology. A key technology for data analysis in high-energy experiments (cost performance, long-term data stores, Green-IT)
  - JAXA, Riken, UTokyo, Meteorological Agency, IBM, KEK, etc.
- Particle physics computing consortium in Japan
  - Sharing computing technology as a standard technology across experimental fields of particle, nuclear, and astrophysics
  - Fostering young leaders of the next generation and career paths through the organization of a summer school for graduate students (IINAS-NX)
  - UTokyo-ICEPP, UKobe, KEK-IPNS/CRC, etc.
- HEPiX forum
  - Information exchange and cooperation with foreign accelerator-related laboratories
  - ASGC, BNL, CERN, DESY, FNAL, IHEP, IN2P3, INFN, JLAB, KEK, KIT, Nikhef, PIC, RAL, SLAC, TRIUMF, etc.
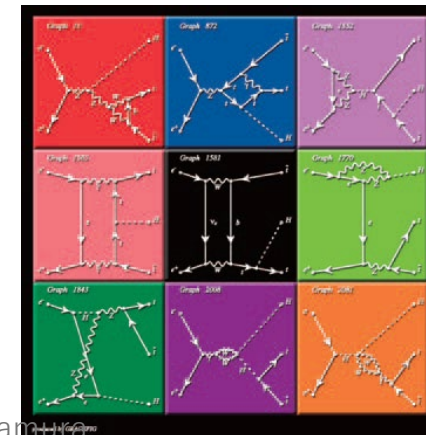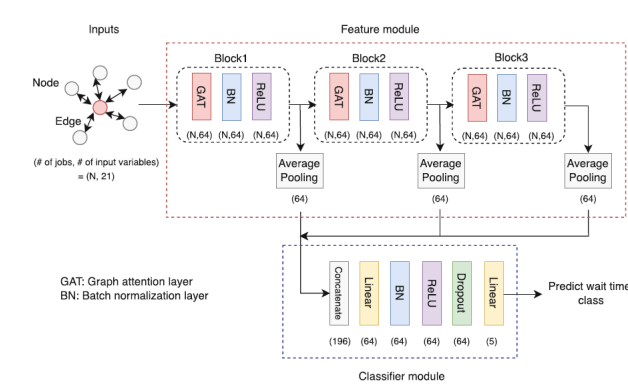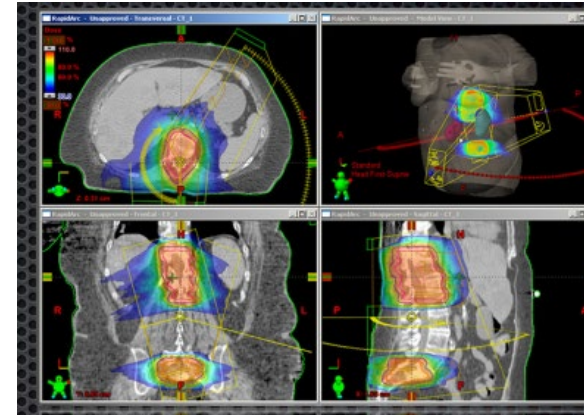
History of the workshop

FJPPL — Japan-France workshop on computing technologies

📅 2025/02/18 9:00 → 2025/02/19 17:30 Europe/Paris

📍 202 (CC-IN2P3)

👤 Sébastien Gadrat (CC-IN2P3)

2025: https://indico.in2p3.fr/event/35206/
2024: https://indico.in2p3.fr/event/31887/
2023: https://indico.in2p3.fr/event/28953/
2019: https://indico.in2p3.fr/event/19919/
2018: https://indico.in2p3.fr/event/16922/
2017: https://indico.in2p3.fr/event/14157/
2016: https://indico.in2p3.fr/event/12701/
2015: https://indico.in2p3.fr/event/11289/

- Workshop in 2024
- 11 and 2 people attended the workshop from CC-IN2P3 and KEK-CRC, respectively.
- 11 presentations presented the status of our respective computing centers, and usage, as well as new methods and tools to face problems and scientific challenges.
- The presentations include a lot of topics, for example, status report and future plans on each computing centers, data analysis method by using deep learning, testing method of batch job system and so on.

Project renewal: COMP_04 to COMP_NEW

- COMP_03: Computing platforms for future experiments
  - FY2015 - FY2018
    - FR leader: Fabio Hernandez
    - JP leader: Tomoaki Nakamura

- COMP_04: Title: Evolution of the computing environment for high-energy and astroparticle experiments
  - FY2019
    - FR leader: Fabio Hernandez
    - JP leader: Tomoaki Nakamura
  - FY2020 - FY2021
    - FR leader: Renaud Vernet
    - JP leader: Tomoaki Nakamura
  - FY2022 - FY2024
    - FR: leader: Sebastien Gadrat
    - JP leader: Tomoaki Nakamura (final year as a leader)

- COMP_NEW
  - FY2025
    - FR: leader: Sebastien Gadrat
    - JP leader: Tomoe Kishimoto

Impact of the Pandemic: 2020 - 2022
- This project has taken a little longer due to the pandemic.
- This year will be my last year as leader of the project.
- We have agreed to start a new computing project in FY2025 with Tomoe Kishimoto as the leader of the Japanese side.