Belle II computing.

Update on infrastructure and activities

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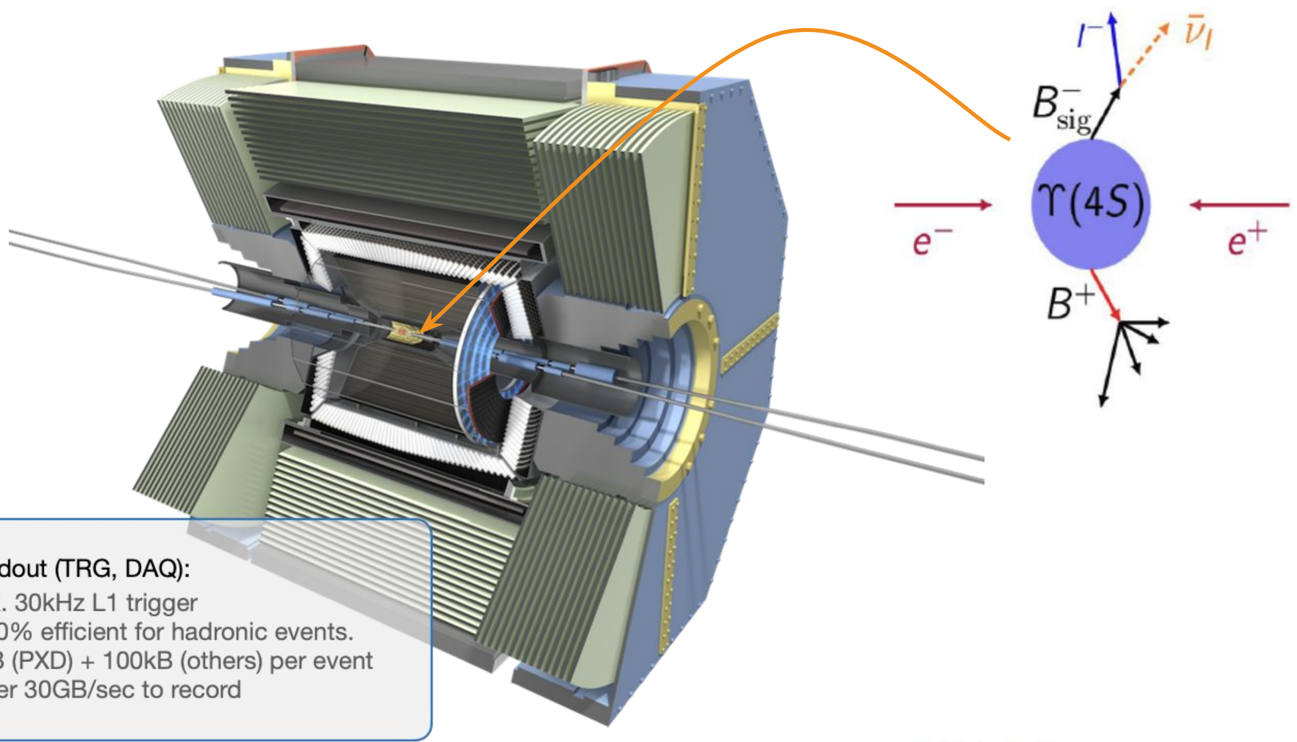
GDB at ISGC

Mar 22, 2023

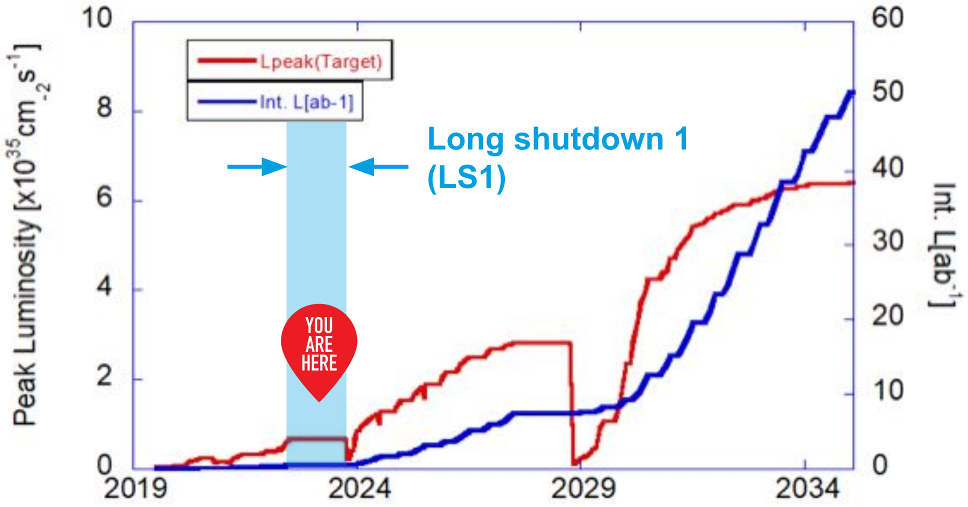
The Belle II Experiment

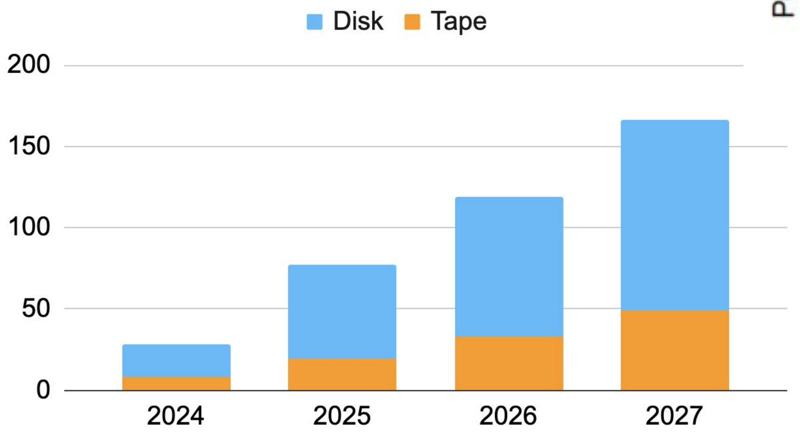
Status



Readout (TRG, DAQ):
Max. 30kHz L1 trigger
~100% efficient for hadronic events.
1MB (PXD) + 100kB (others) per event
- over 30GB/sec to record

- More than 2 PB of RAW Data Collected so far, since 2019.
- Currently we are in Long Shutdown for upgrade.
  - Data taking will be resumed in Oct. 2023.

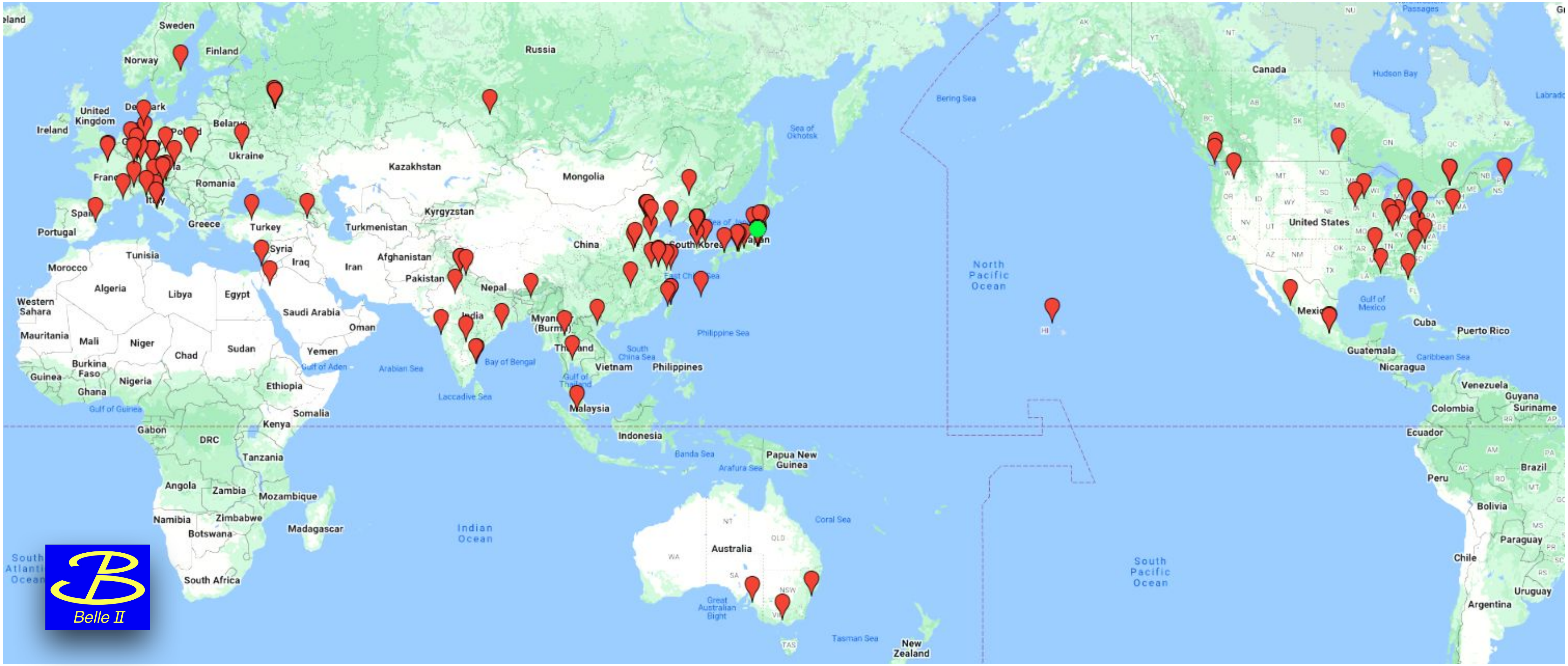




- After the restart, the estimated size of the dataset collected by the experiment is **~ O(10) PB/year.**

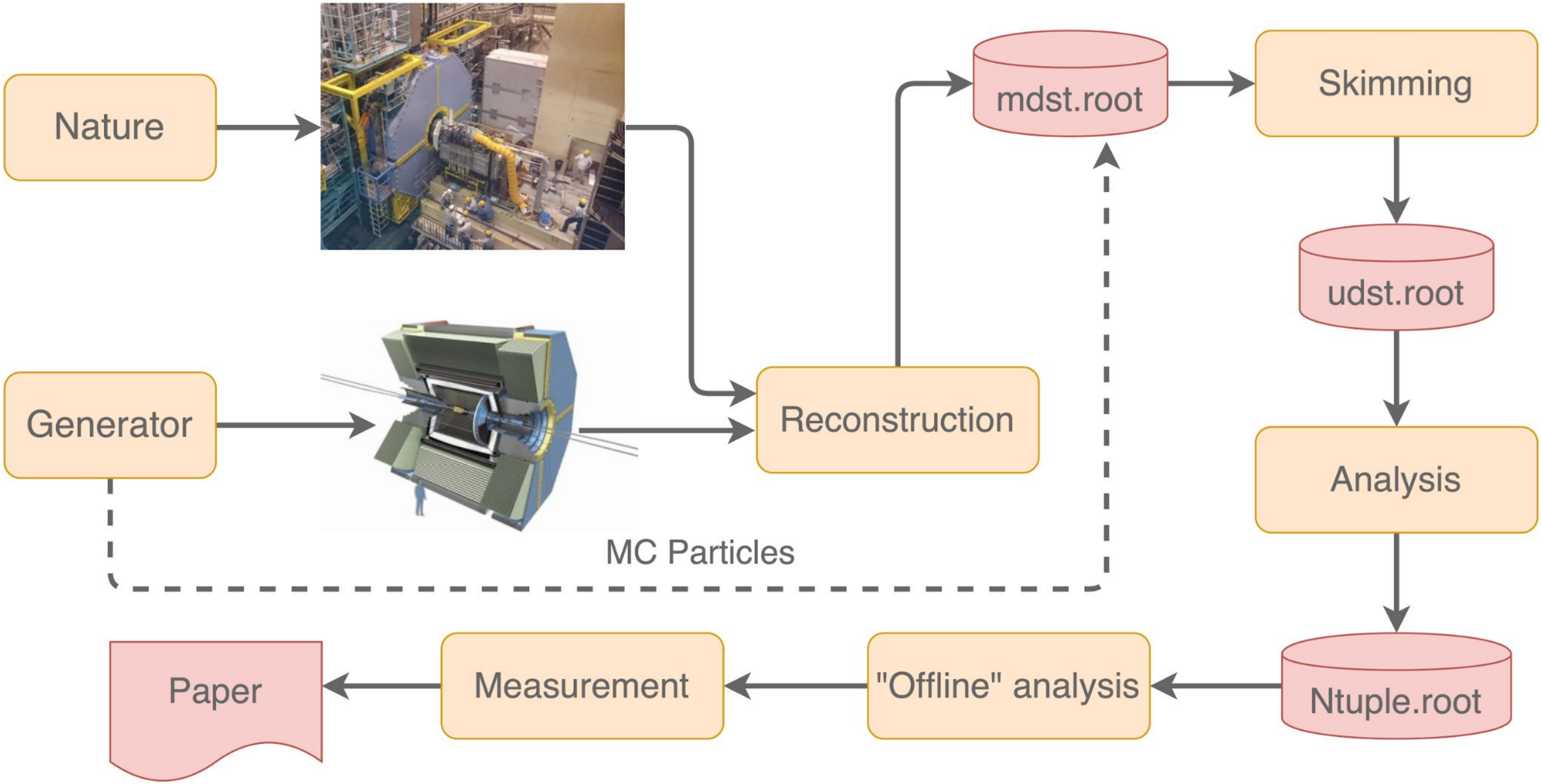
The Belle II Experiment

1180 members, 131 institutions, 27 countries



Belle II Data Model

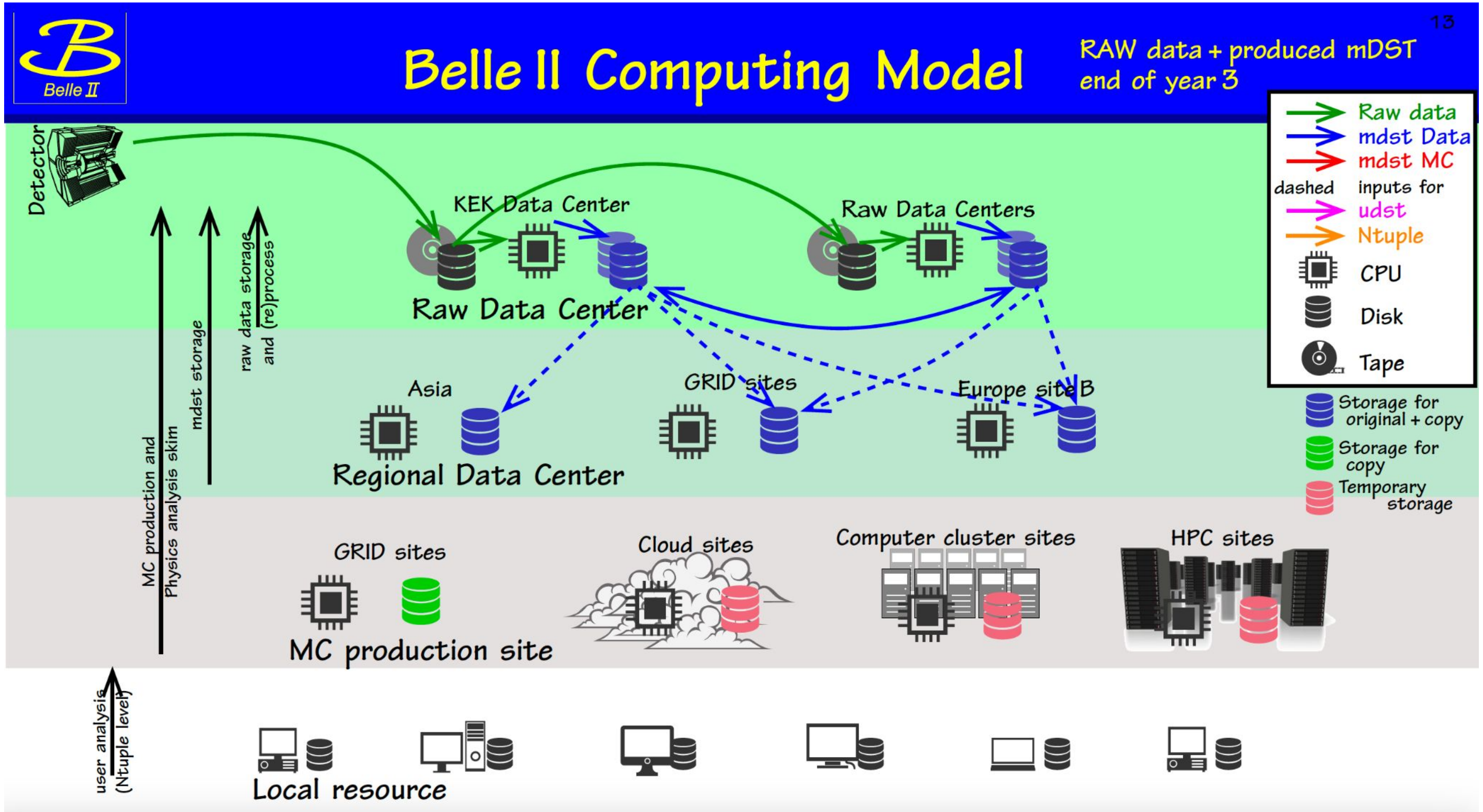
From data taking to physics results



Belle II Computing Model

Data transfer and processing

- Data is transferred from the online servers to the KEK data center.
- Six raw data centers around the world keep a second replica of the full raw data set.
- Raw data is processed at the Raw data centers, skimmed and distributed over Raw and Regional Data Centers.
- MC production is performed at grid sites.
- Users access data and MC sending jobs to the grid and downloading the output to local resources.



Distributed computing infrastructure at Belle II

Sites status in 2022

- **Storage Elements (SEs)**
  - 29 storage sites. 6 Tape systems.
    - 92% of Storage on LHCONE.
    - 11.3 PB reachable via IPv6 over of 15.5 PB.
    - All sites except 3 support HTTP/WebDAV.

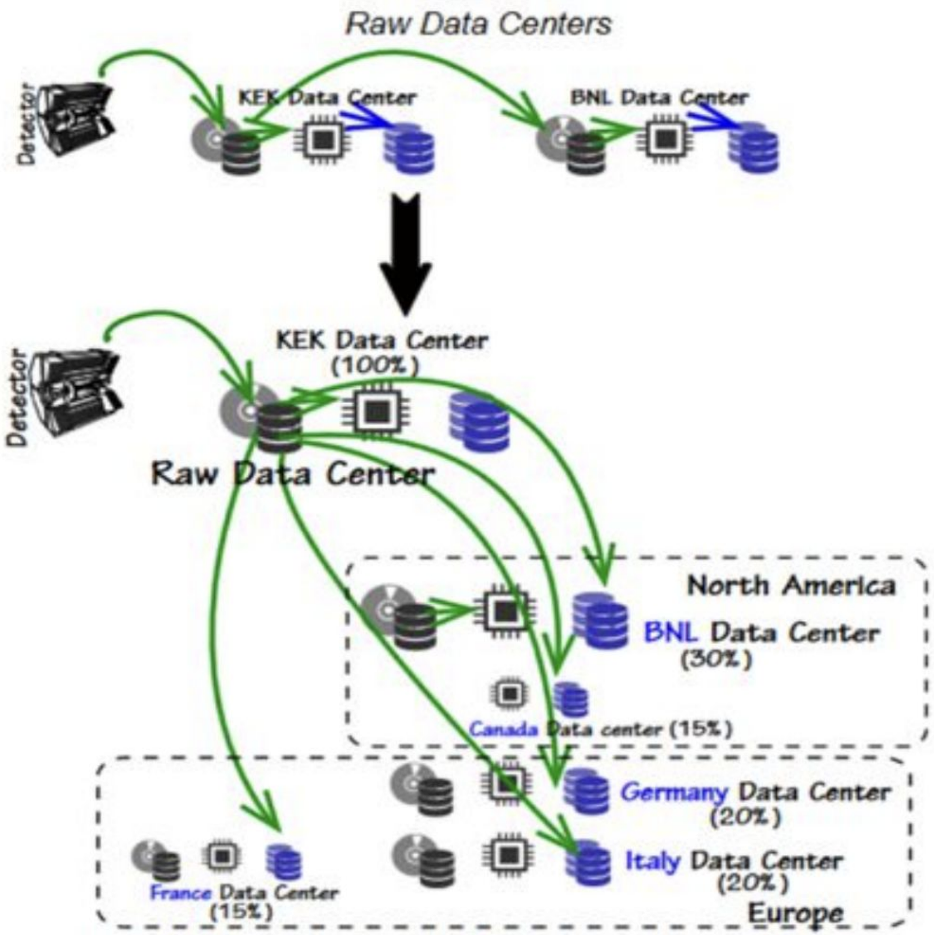
- **Sites (CEs)**
  - 55 sites registered in DIRAC.
    Some sites with multiple CEs.
  - Most part of the sites (49) are EL7 based.

Storage	Space (PB)
Disk	15.5
Tape	12.4

CPU	kHS06	Job slots
Provided CPU	452	31,484

Raw data distribution

Raw data centers



- We have gradually implemented the full RAW Data distribution schema, starting to distribute them since 2021.
  - Nominal share:

SITE	2019-2020	2021-2024
BNL - USA	100%	30%
CNAF - Italy	0%	20%
DESY - Germany	0%	10%
KIT - Germany	0%	10%
IN2P3CC - France	0%	15%
UVIC - Canada	0%	15%

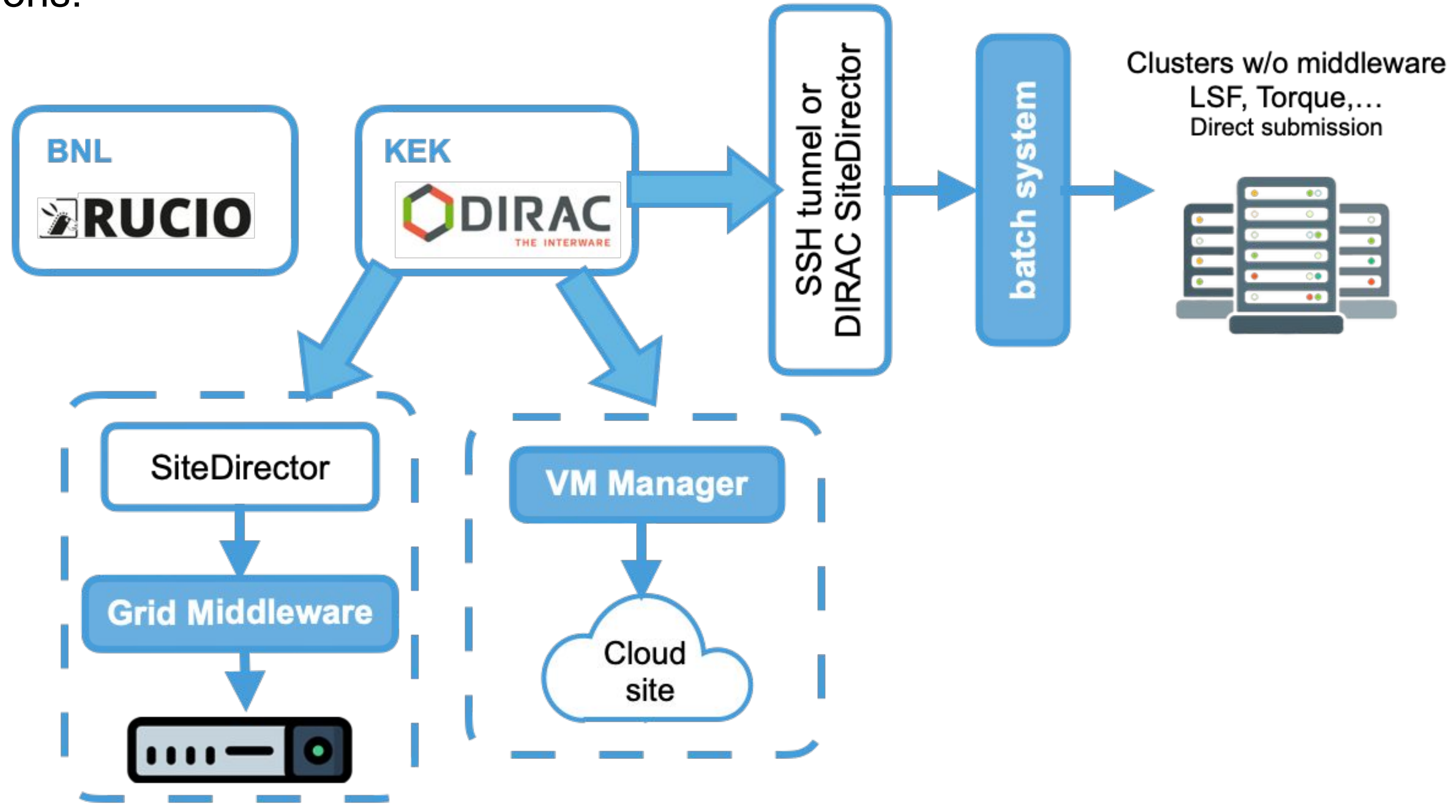
Distributed computing infrastructure at Belle II

Interoperability with DIRAC

- We adopted DIRAC as the main framework to interact with distributed computing systems.
- Rucio for distributed management operations.

- Computing resources with various implementations:
  - Grid:
    ARC-CE, HTCondor-CE, CREAM-CE
  - Clusters w/o middleware:
    ssh or DIRAC SiteDirector
  - Cloud: VCYCLE

- Other grid services
  - FTS
  - VOMS - VO belle
  - AMGA - Metadata Catalog
  - CVMFS - Software (basf2) and
    DIRAC + BelleDIRAC tarballs distribution



Usage of Rucio in Belle II

Highly-scalable, policy-driven data management system

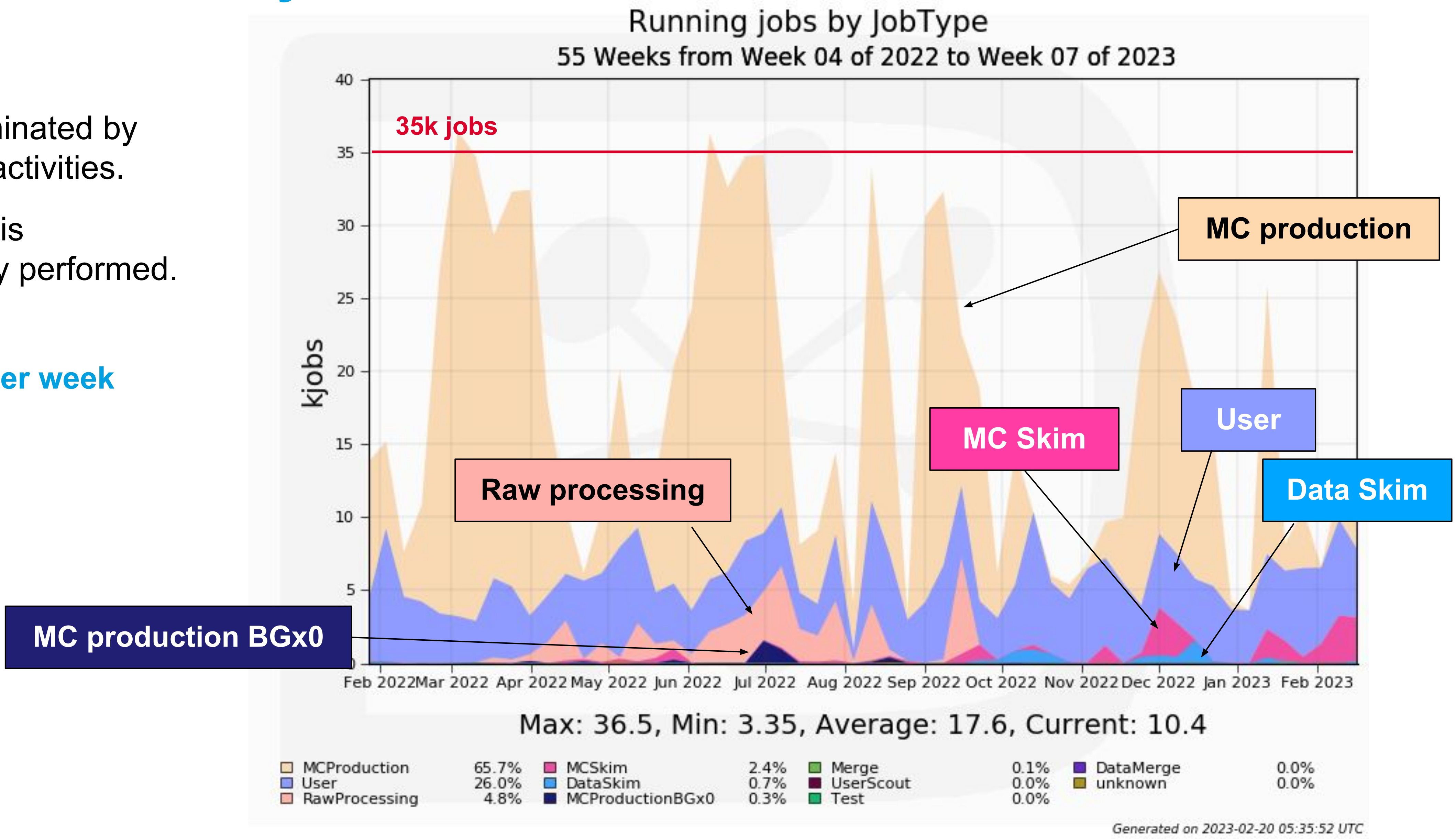
- In Belle II, we use Rucio as:
  - **Distributed Data Management System (external to DIRAC)**
    - Transfers between sites using policies engines (rules and subscriptions).
    - Monitoring for transfers, deletions, SE occupancy.
    - Details: Rucio at Belle II (vCHEP 2021)
  - **File Catalog plugged in to DIRAC**
    - Provide coherent access to file replicas via Logical File Names (LFNs).
    - Ongoing work to support metadata.
    - Details: Rucio FC in DIRAC (vCHEP 2021)
- Rucio client APIs are being integrated into our end-user client tools
  - replication rules + replica lifetime, async deletion, etc.
- Gradually enabled more features from Rucio.

Operation Summary

Last year

- Activity dominated by production activities.
- User analysis continuously performed.

1.3M jobs per week



MC production

Raw processing

MC Skim

User

Data Skim

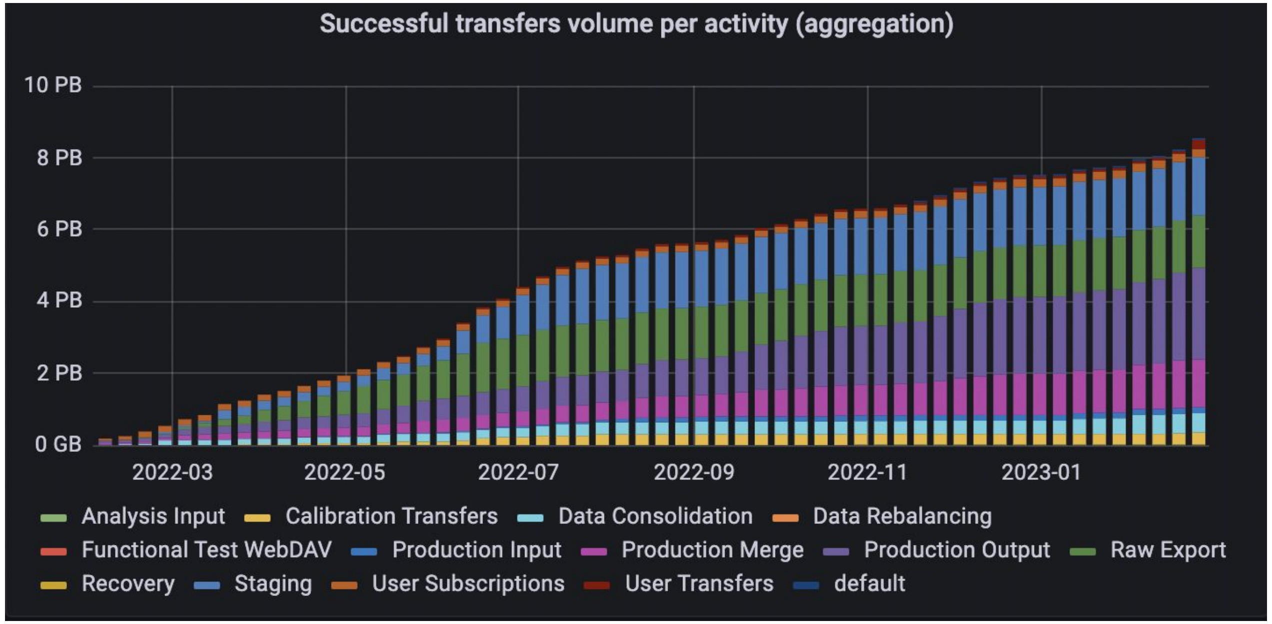
MC production BGx0

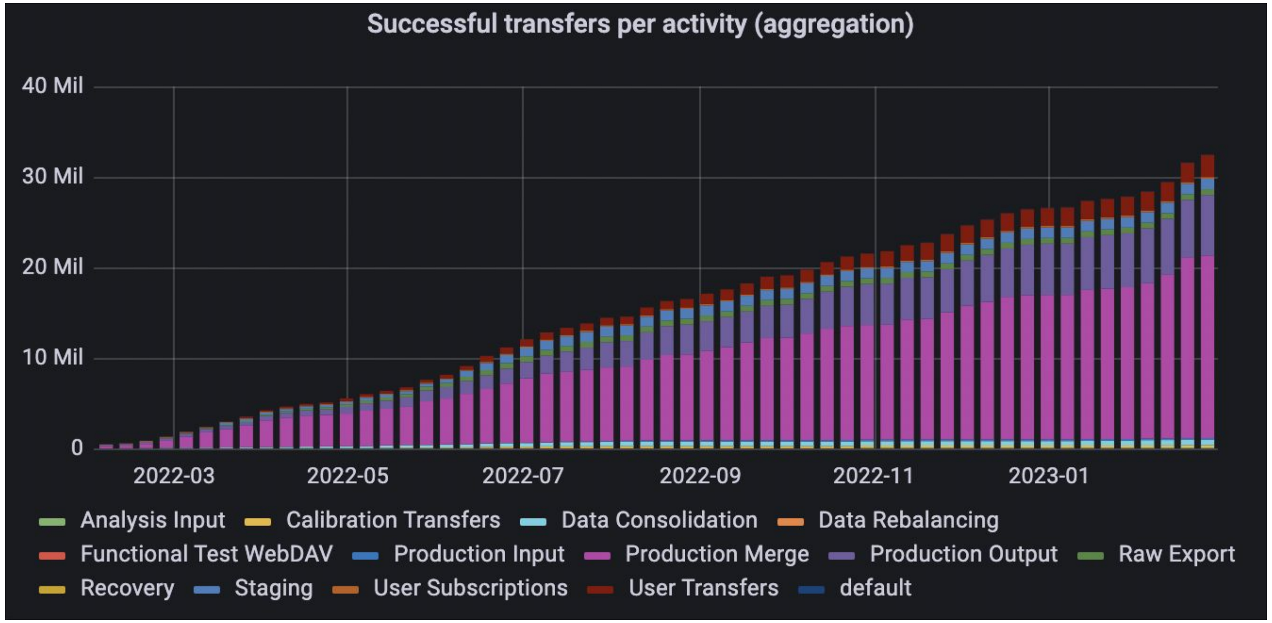
Generated on 2023-02-20 05:35:52 UTC

Successful transfers

Last year

- Data movement between SEs managed by Rucio rules.
- FTS servers at KEK & BNL.
- Traffic
  - Average: 33 TB/day.
  - Peak: 110 TB/day.
- Estimated mean after data taking restarting ~60 TB/day.

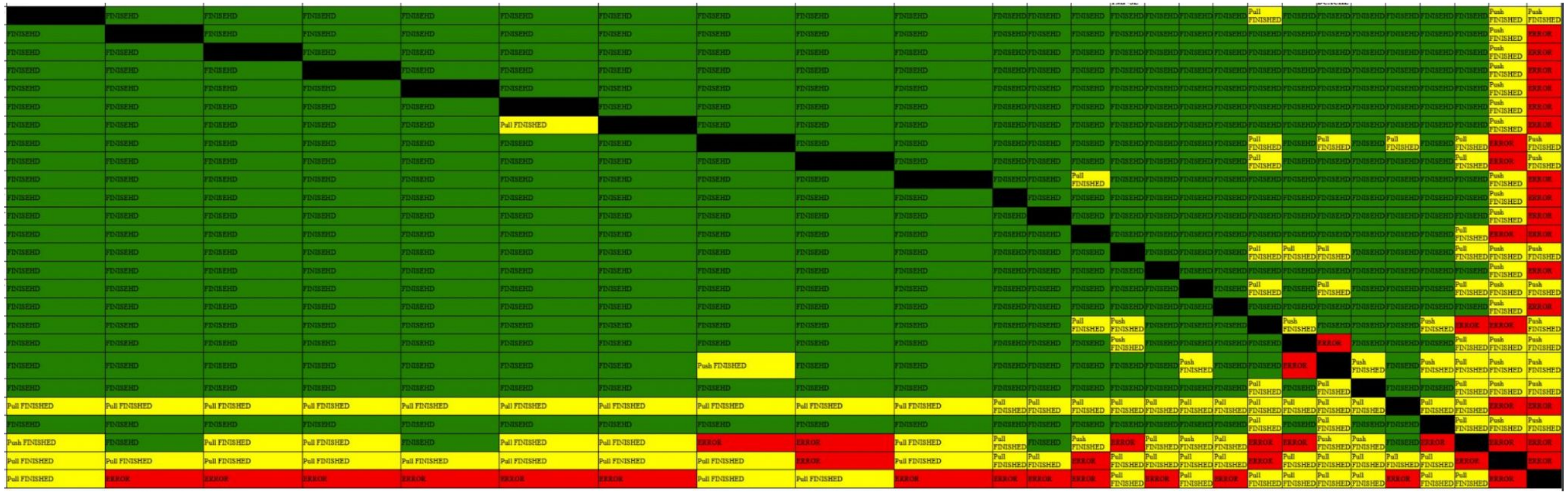




Site Configuration

Protocol for data access

- Moving away from GSIFTP in line with WLCG plans.
- Current status:
  - Transfers with https/WebDAV from 37% in early 2022, to **93% in Feb 2023.**
  - Still a lot of transfers involving SRM when reading from TAPE.
- Tests with third-party-copy constantly performed:



Green: transfers successful.

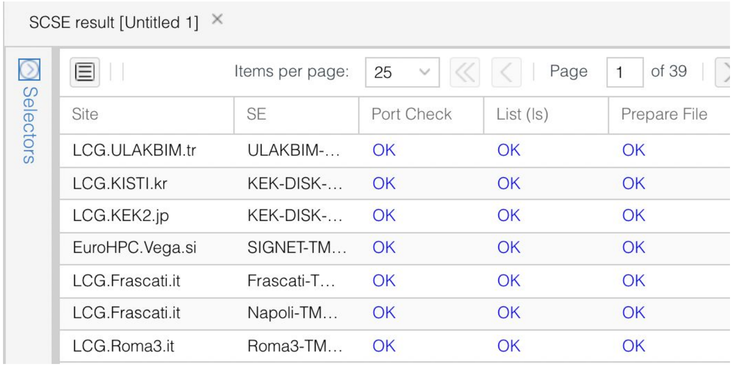
Yellow: at least a pull or push completed.

Red: all transfers failed.

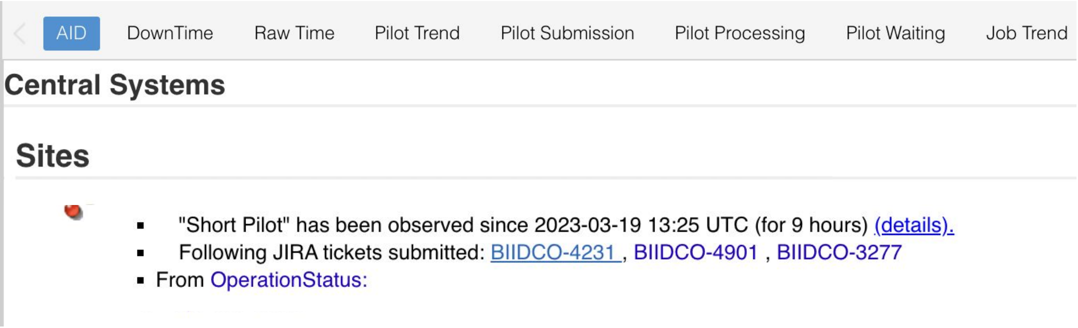
Monitoring of operations

Services used by Belle II

- We rely on several services for monitoring activities.
  - We use DIRAC & Rucio for our own monitoring and accounting.
    - Periodically checks on sites: test execution for Belle II software, upload/download of files, etc.
    - Human-readable operation summary used by shifters.
  - **EGI accounting** for yearly report of CPU consumption.
  - For reporting issues to sites, we use **GGUS**.
  - For monitoring downtimes, we use **GOCDB**.



Site	SE	Port Check	List (ls)	Prepare File
LCG.ULAKBIM.tr	ULAKBIM-…	OK	OK	OK
LCG.KISTI.kr	KEK-DISK-…	OK	OK	OK
LCG.KEK2.jp	KEK-DISK-…	OK	OK	OK
EuroHPC.Vega.si	SIGNET-TM…	OK	OK	OK
LCG.Frascati.it	Frascati-T…	OK	OK	OK
LCG.Frascati.it	Napoli-TM…	OK	OK	OK
LCG.Roma3.it	Roma3-TM…	OK	OK	OK



Central Systems

Sites

- "Short Pilot" has been observed since 2023-03-19 13:25 UTC (for 9 hours) (details).
- Following JIRA tickets submitted: BIIDCO-4231 , BIIDCO-4901 , BIIDCO-3277
- From OperationStatus:

Monitoring of operations

Overview

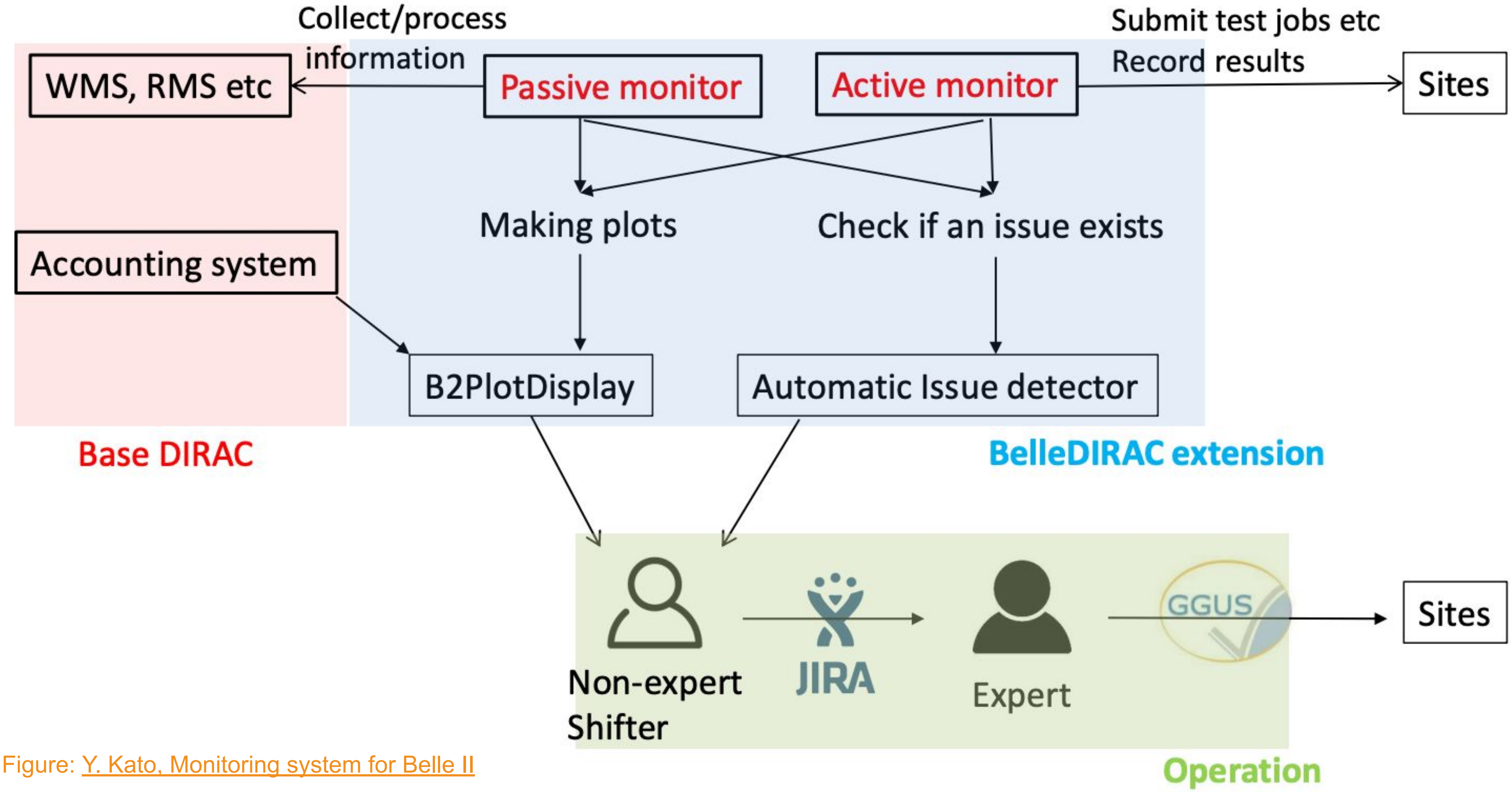


Figure: Y. Kato, Monitoring system for Belle II

Token-based authentication

Testbed

- Following WLCG and OSG agenda, Belle II is working to support token based authentication.
  - Many of the Belle II sites are also WLCG sites.
- Resources tested for now with CNAF IAM Service.
  - IAM pre-production instance available at KEK.
- Testbed for job submission
  - HTCondor-CE: CNAF, BNL, DESY, Napoli, CC-IN2P3, KIT, Roma3
  - ARC-CE: KEK
- Storage Elements: KEK, CNAF (STORM), IN2P3CC (dCache)
  - Test: full set of ls, mkdir, copy, delete with both null and production role implemented via optional group.

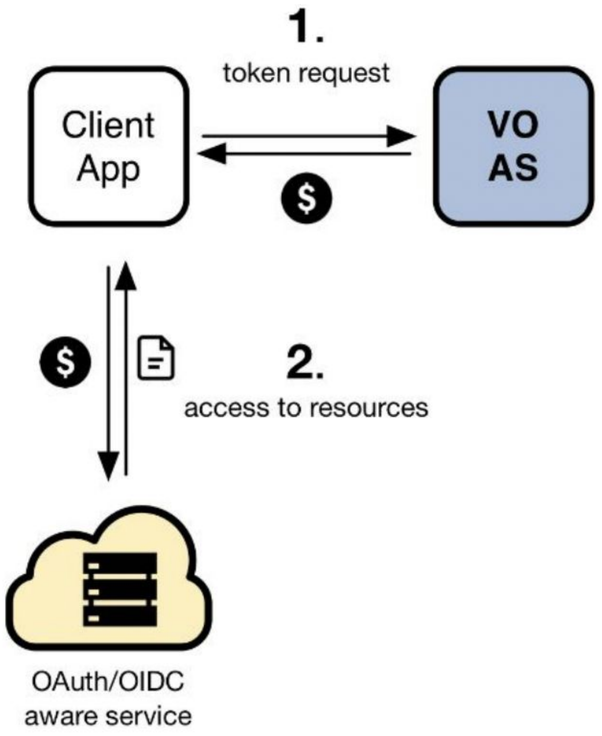
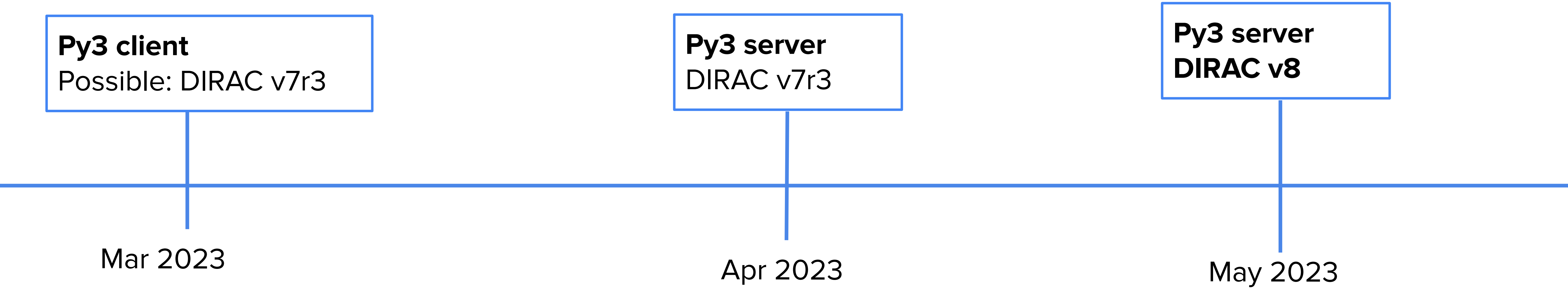


Figure: A. Ceccanti, ESCAPE AAI Webinar

DIRAC migrations

And Python 3

- Plan defined for moving to DIRAC v8.0 for Token Based Authentication.
  - Currently, we use DIRAC v7r2 in production.
- First milestone: deploying a py3 client on Mar 2023.
  - On certification. Testing if DIRAC v7r3 can be migrated on this iteration (still, Python2 on server).
- Full Python3 migration in our services is a top priority task.
  - DIRAC v8.0 & Rucio 1.29.x no longer support python2.



Py3 client
Possible: DIRAC v7r3

Mar 2023

Py3 server
DIRAC v7r3

Apr 2023

Py3 server
DIRAC v8

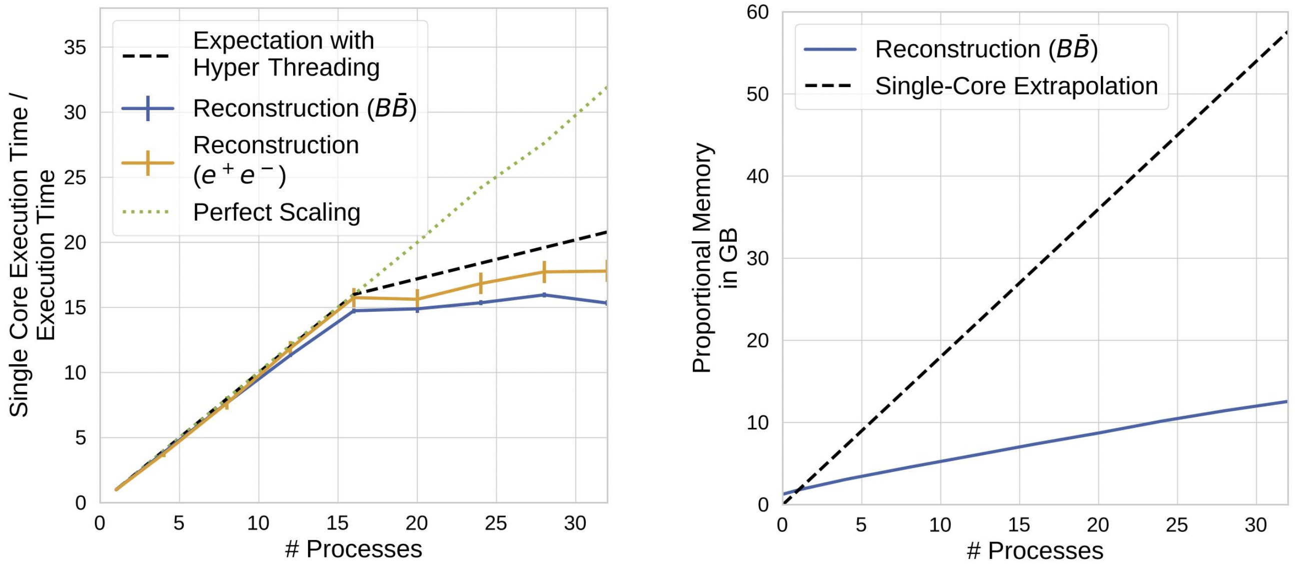
May 2023

Multicore jobs

A more efficient usage of resources

- Working for enabling multi-core job processing .
  - Processing throughput per job (8x more events per job) = less number of jobs.
  - Less merge steps = less pressure on SEs.
- The Belle II software framework provides a parallel-processing feature. Each of the threads processes the data of a separate complete event.
  - Performed via a call to fork() . After a new child process is created, both processes will execute the next instruction following the fork() system call.
- The Software group have verified up to 20 concurrent processes for typical Belle II jobs and event data sizes.
- Currently performing job tests with 8 cores in raw data reprocessing sites.

Tests on 16-core node.



Data Challenge 2024

Belle II participation

- Belle II has confirmed its intention to participate in the Data Challenge 2024.
  - As we share major parts of the infrastructure with LHC experiments.
  - Early internal discussions in preparation for the DC24.
    - We will join the DOMA General meeting (29th March).

- Goal: emulate data transfer conditions in a Belle II high-lumi scenario.
  - Our current estimation for such scenario is 40 TB per day.
  - Transfers to raw data centers according to our distribution schema.

- **A concern: the data challenge likely overlaps with Belle II data taking.**
  - Estimated restart for October 2023.
  - Actual restart depends on replacement operations being performed at KEK.
  - The concern was expressed to the WLCG management board. We will keep close communication.

Summary

- The distributed computing system of Belle II adopted DIRAC and Rucio as main management systems.
  - We keep integrating our tools with Rucio capabilities.
- Computing and data production activities stable.
  - Belle II will restart data taking operations by late 2023, expecting to handle O(10) PB per year.
- Operations with token-based authentication and authorization in preparation.
  - Testbed prepared, and some command-level tests have been performed.
- Plan to migrate to DIRAC v8.0 by mid 2023. Preparing migration to DIRAC v7r3.
- Other improvements in preparation.
  - Third-party copy with https/WebDAV.
  - Enabling muticore jobs for data reprocessing.
- We will participate in the data challenge 2024.
  - Overlaps with Belle II data taking. We will keep the board updated.

Backup

Distributed computing infrastructure at Belle II

Central services

- **Production**
  - 11 DIRAC servers + 4 DB servers + 2 Web servers (KEK)
  - DIRAC server for non-grid sites (batch job submission via SSH).
  - Cloud Scheduler (University of Victoria); Vcycle (Napoli).

  - Rucio server (BNL)
  - FTS servers (KEK & BNL)
  - CVMFS (KEK, CERN) for DIRAC and Basf2 distribution.
- **Test servers at BNL**
  - Certification: validation of new BelleDIRAC releases.
  - Migration: test of base DIRAC upgrades.
- **Development**
  - Multiple instances at KEK, BNL, Mississippi, etc.

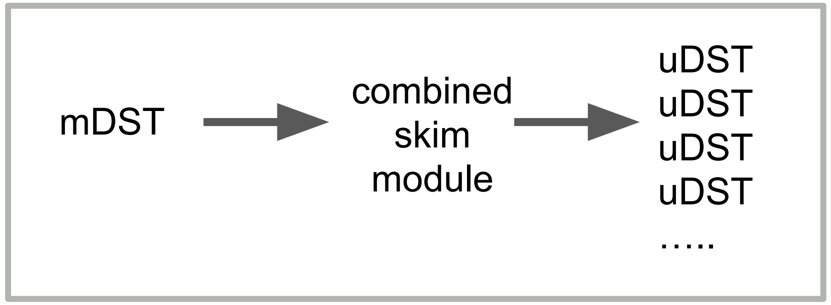
KEK

Brookhaven™
National Laboratory

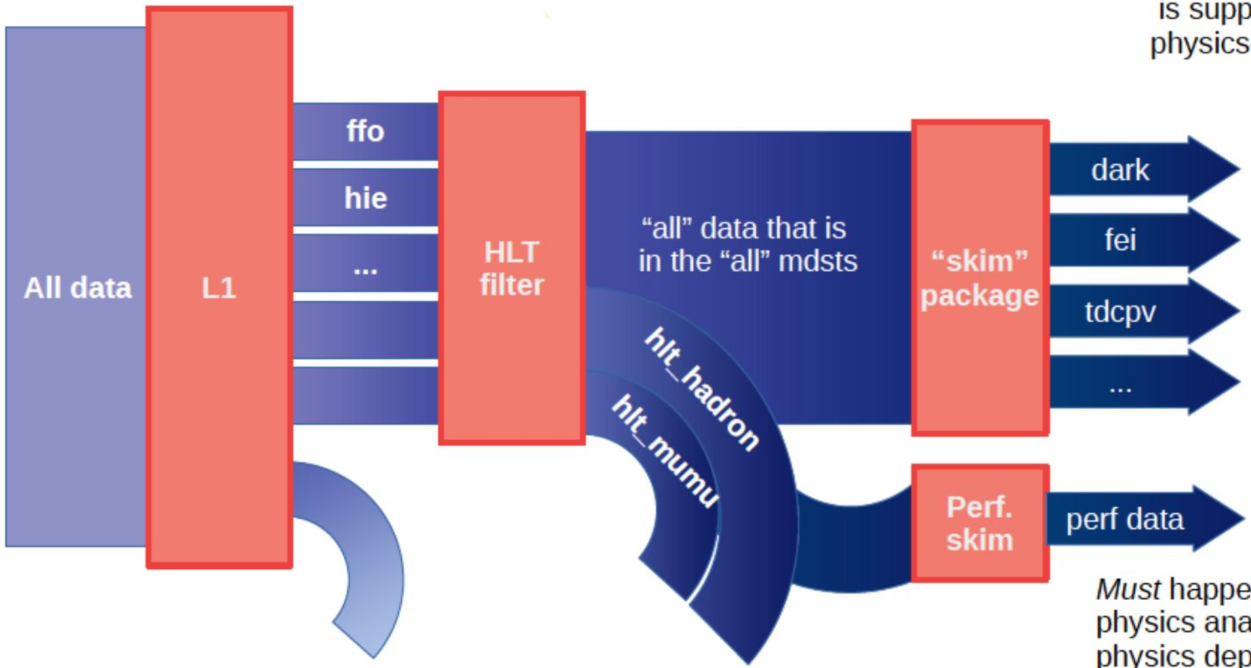
INFN
NAPOLI

Skimming

- To produce data and MC files that have been reduced from their original size, according to the analysis requirements of each physics working group.
- Python-based classes developed by liaisons of each WG.
- Skim usage for analysis is highly correlated with grid performance.
- Requirements:
  - Retention should be less than 10%.
  - Processing time should be less than 500 ms per event.
  - Maximum memory usage is 2GB.



Key:
Red is a filter
Blue scale from light to dark is supposed to indicate more physics-relevant data



Random background events for overlay

HLT skims calibration / dqm

Must happen faster than physics analysis skims: physics depends on performance analyses

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