

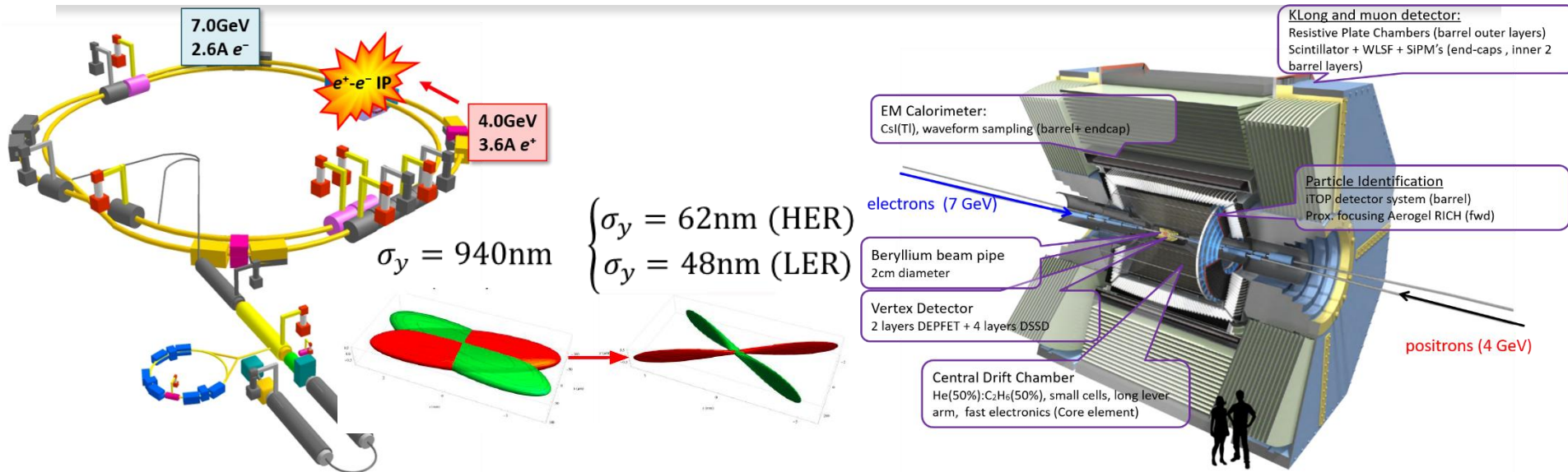
Belle II

Y. Kato (KMI, Nagoya)



SuperKEKB/Belle II: in a nutshell

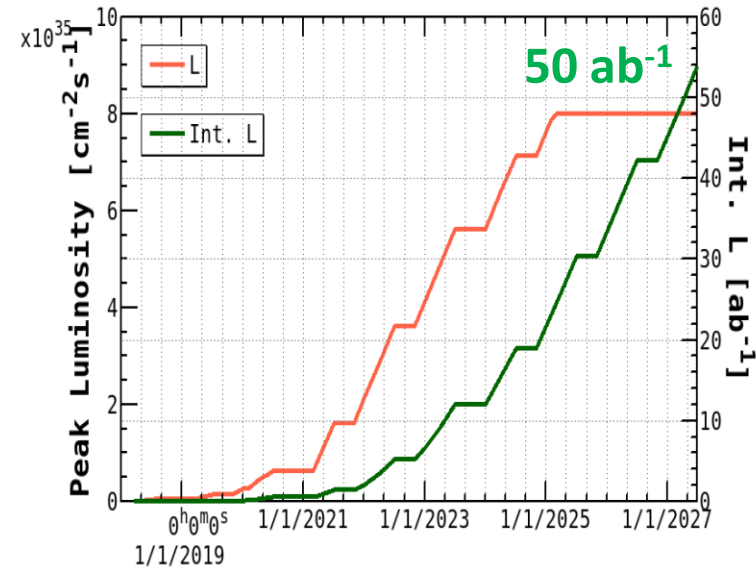
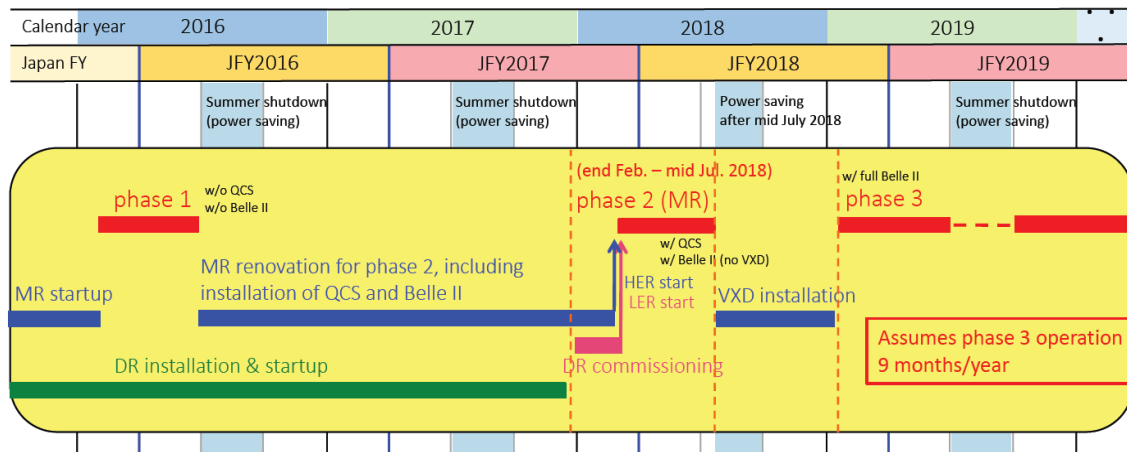
2



- **Intensity frontier** e^+e^- collider B-factory experiment with peak luminosity of $8 \times 10^{35} \text{ cm}^{-2}\text{s}^{-1}$ (40 times of KEKB).
- Detector is also upgraded to improve performance and to cope with huge beam background.
- More than **900 Physicists** from ~ 100 institutes in 25 countries/region

Schedule

3

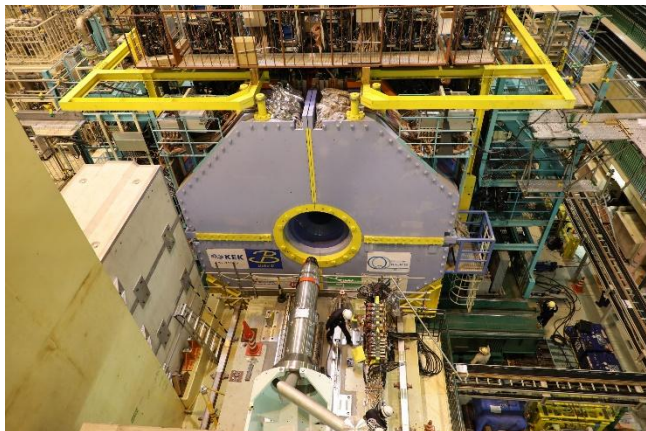


- Plan to accumulate **50 ab⁻¹** (x50 times of Belle)
- Phase1:** SuperKEKB commissioning w/o final focusing and w/o Belle II detector
- Phase2:** Collision data taking w/ final focusing. No VXD (2018 Apr-Jul, 500 pb⁻¹)
- Phase3:** Collision data taking w/ full Belle II detector (2019 Mar): **Just started!**

Highlights

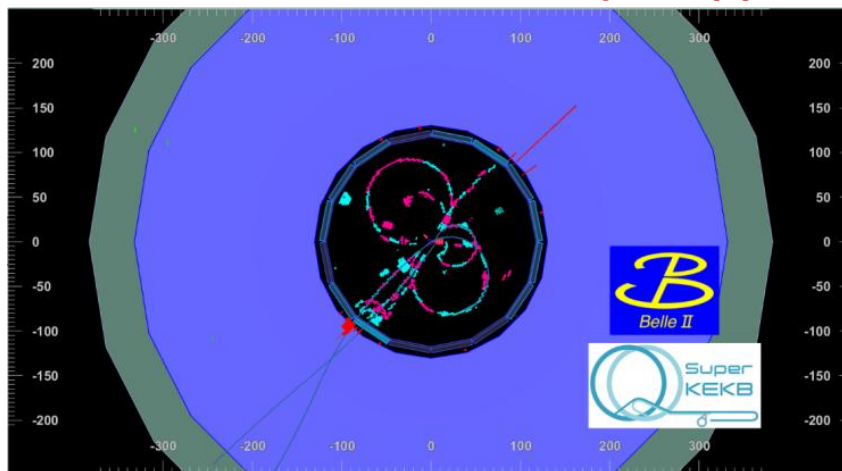
4

Belle II roll-in



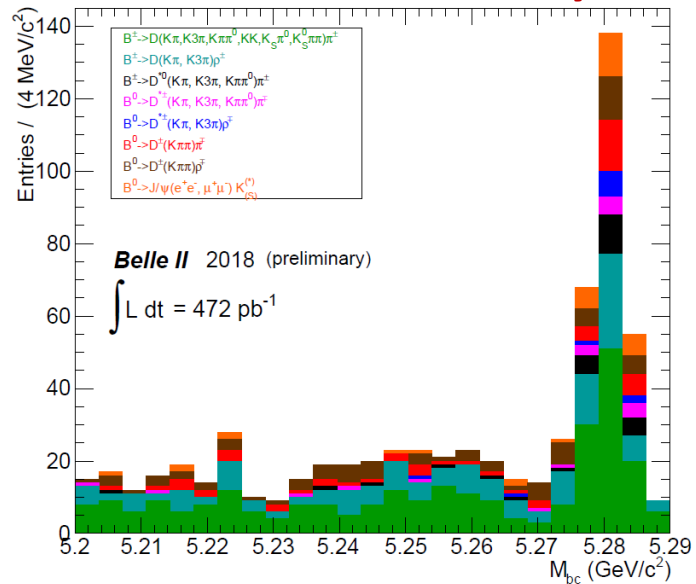
Apr 11, 2017

First collisions! $e^+e^- \rightarrow \gamma^* \rightarrow qq$

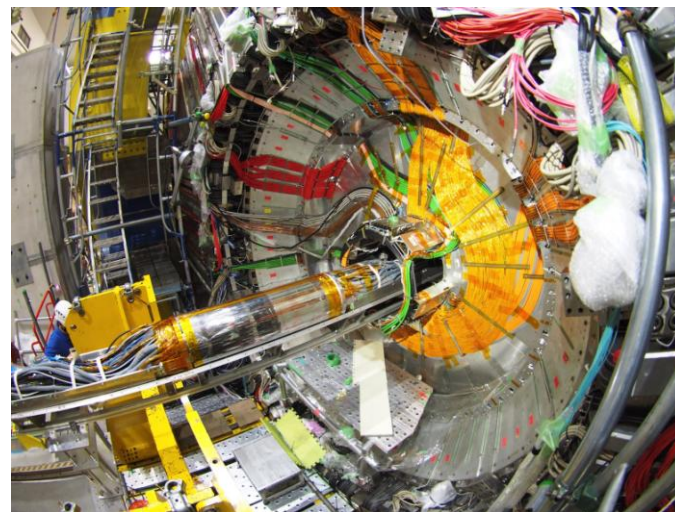


Apr 26, 2018

B meson re-discovery



VXD installation



Nov 26, 2018

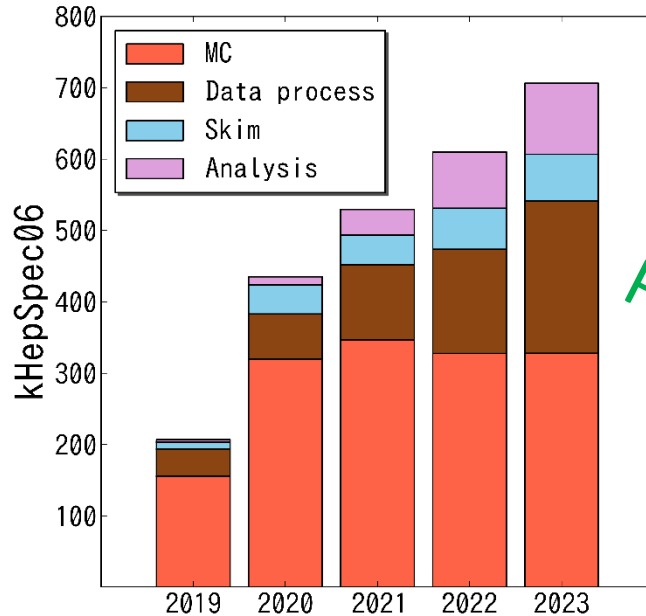
HOW 2019

4

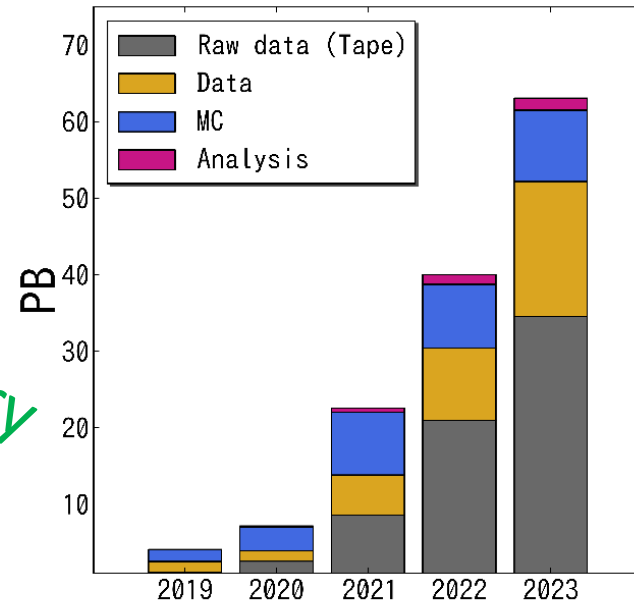
Computing resource requirements

5

CPU



Storage



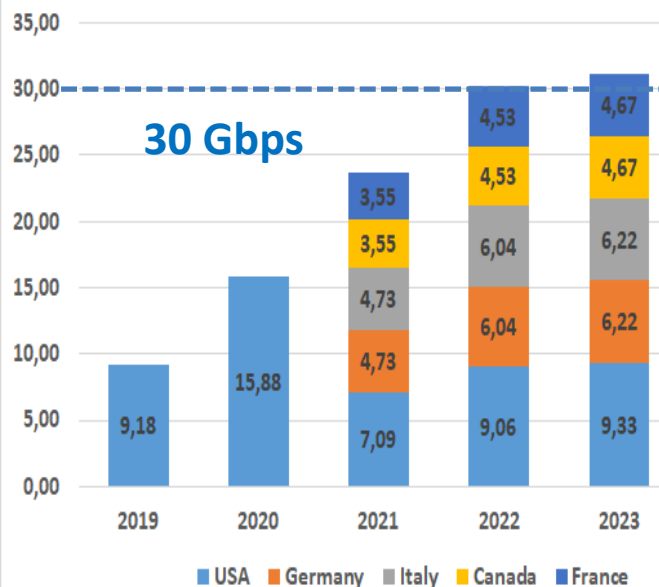
Preliminary

- Up to **2023** ($\sim 15 \text{ ab}^{-1}$)
- More than half of CPU usage for MC production.
- One copy for raw data.
- Finally, **$O(10^3)$ kHepSpec CPU, $O(100 \text{ PB})$ storage** are needed.

Network requirement

6

RAW-Data Inbound Max Bandwidth (Gbps)



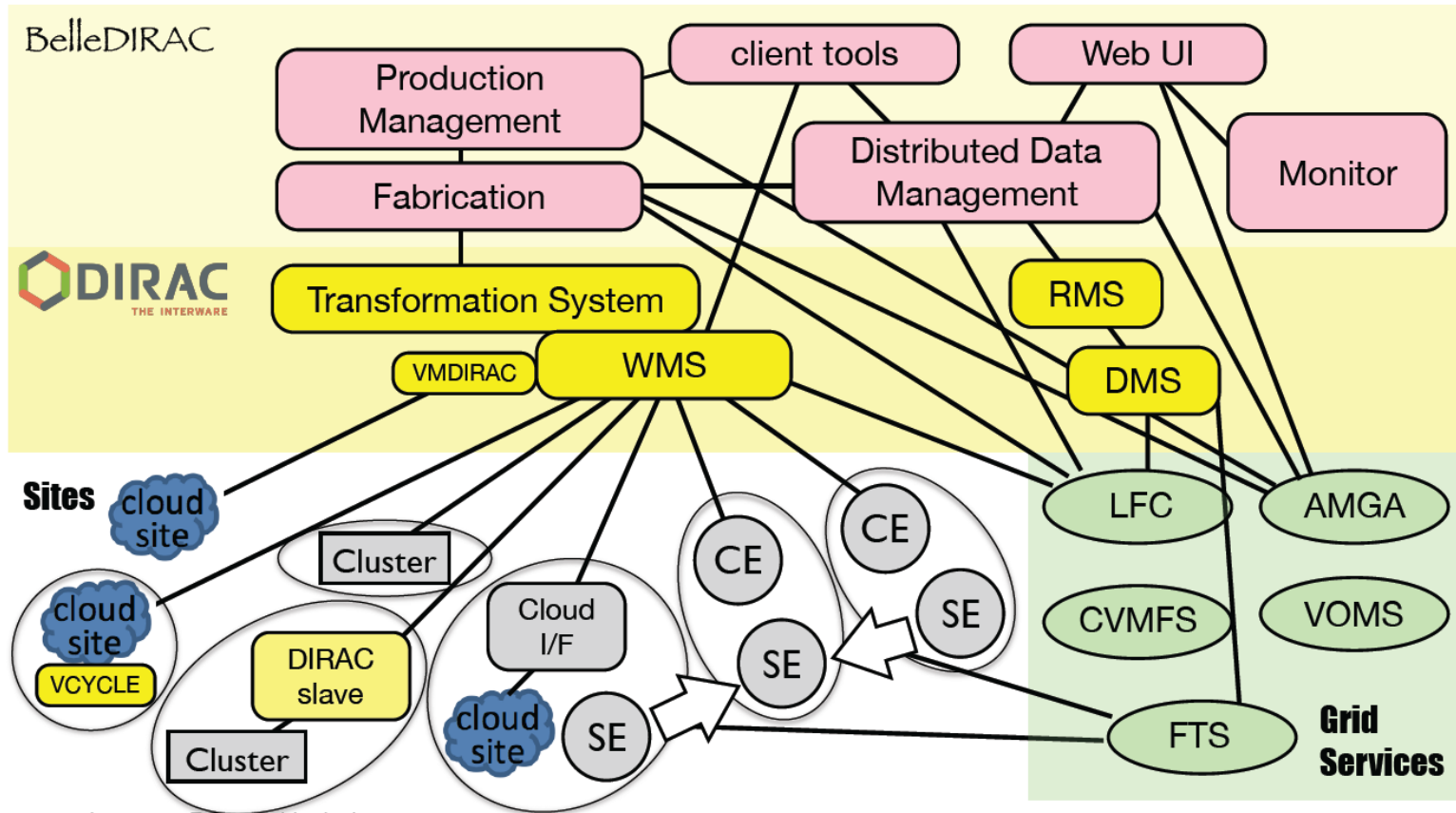
- **Raw data copy** is the biggest deal.
 - First two years to BNL only
 - Shared with other areas after that.
- **~30 Gbps** is needed from KEK to the world.
- KEK is connected to US/Europe with 100 Gbps now

	DC 2018		DC 2013-2017	DC 2018		DC 2013-2017
	From KEK (peak)	From KEK (average)	From KEK (peak)	To KEK (peak)	To KEK (average)	To KEK (peak)
CNAF	20	15.3	18	18.1	16	9.2
DESY	15.9	10,4	6	16.7	11.7	11
KIT	20	13.2	5.6	20	12.4	3.2
BNL	35.5	15.5	12	20.8	15.7	12.8
UVIC	13.4	10.5	/	21.9	16.6	/
SIGNET	7.3	6.7	1.6	10	8.5	3
IN2P3	Do be done	Do be done	/	Do be done	Do be done	/

Belle II distributed computing system

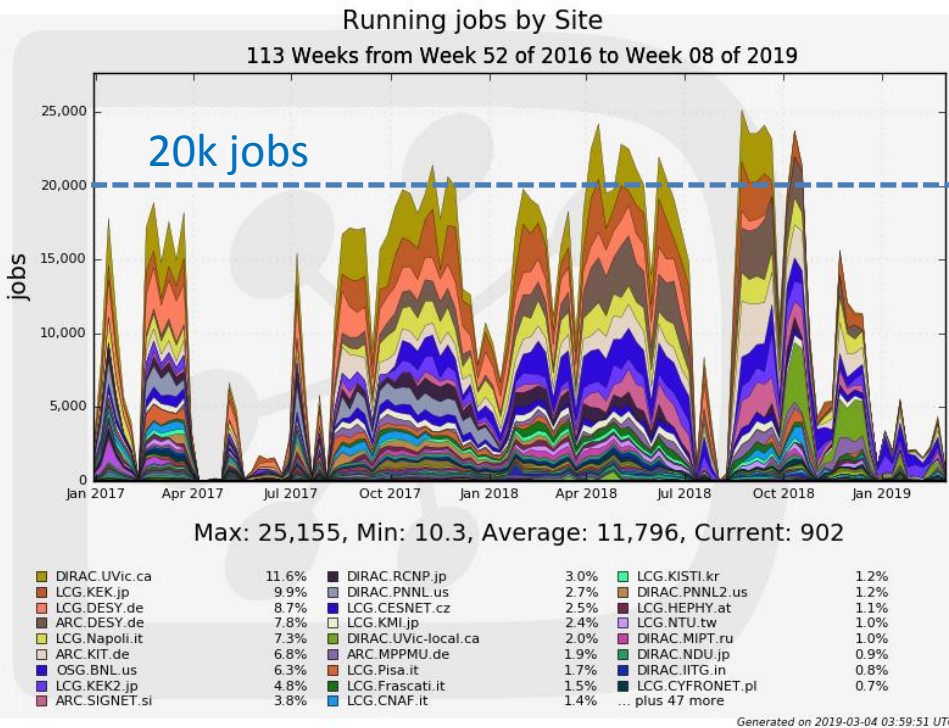
7

Production Manager Data Manager End Users Operations

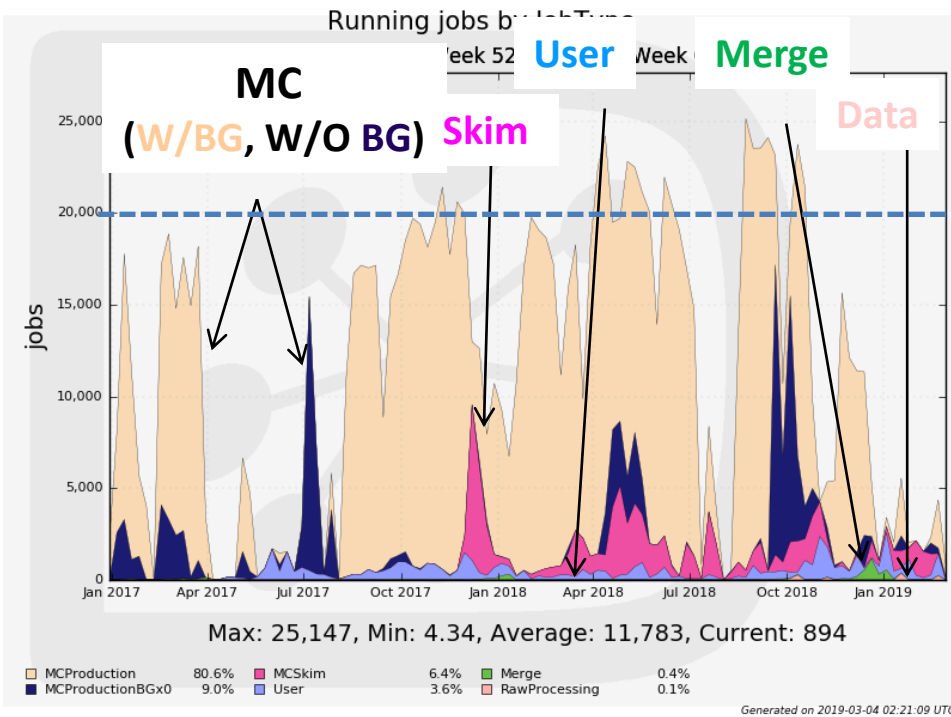


- BelleDIRAC: An extension of DIRAC.
- DIRAC handles jobs and files \leftrightarrow production system handles “productions” and “datasets”.
- Distributed Data Management (DDM) to distribute/relocate data
- Software/condition data distribution via CVMFS

Sites



Type

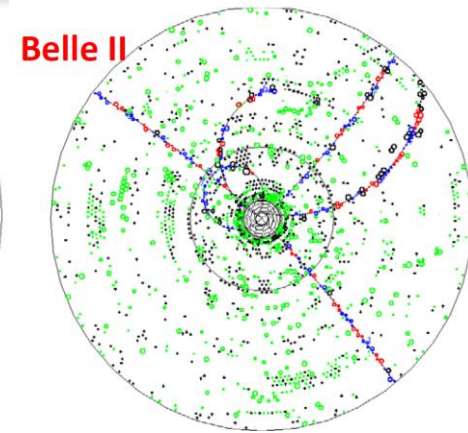
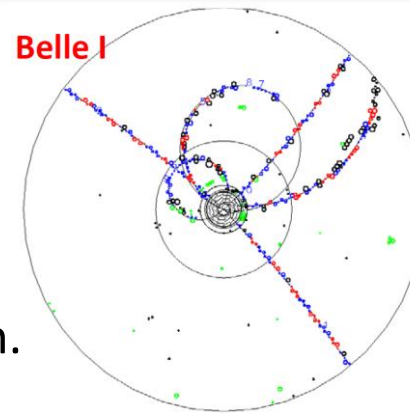


- $\sim 2 \times 10^4$ jobs constantly running
- ~ 50 sites join. Mainly grid sites. Sizable contribution local cluster sites.
- Mainly for MC now.

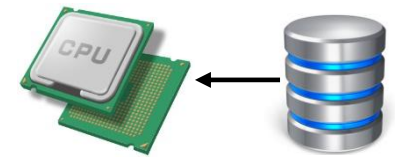
Beam background

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- Huge beam BG compared with Belle.
 - Possible efficiency/resolution degradation
 - Essential to implement properly
 - Largely depend on the acceralator condition.
- Need run dependent BG simulation.

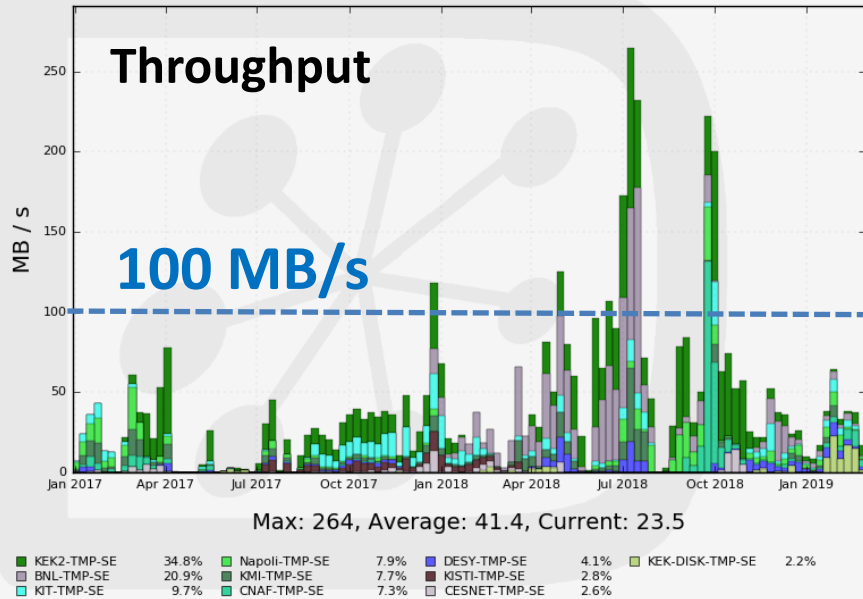


- BG files are prepared beforehand, and “overlaid” in simulated event.
- They are distributed to SEs or shared places.
- Even in early phase3 only, total amount is several TB to assure randomness.
 - Difficult to put in local cluster sites.
 - Put part of BG files depending on the CPU resources.
- How to distribute run dependent beam BG is under discussion.



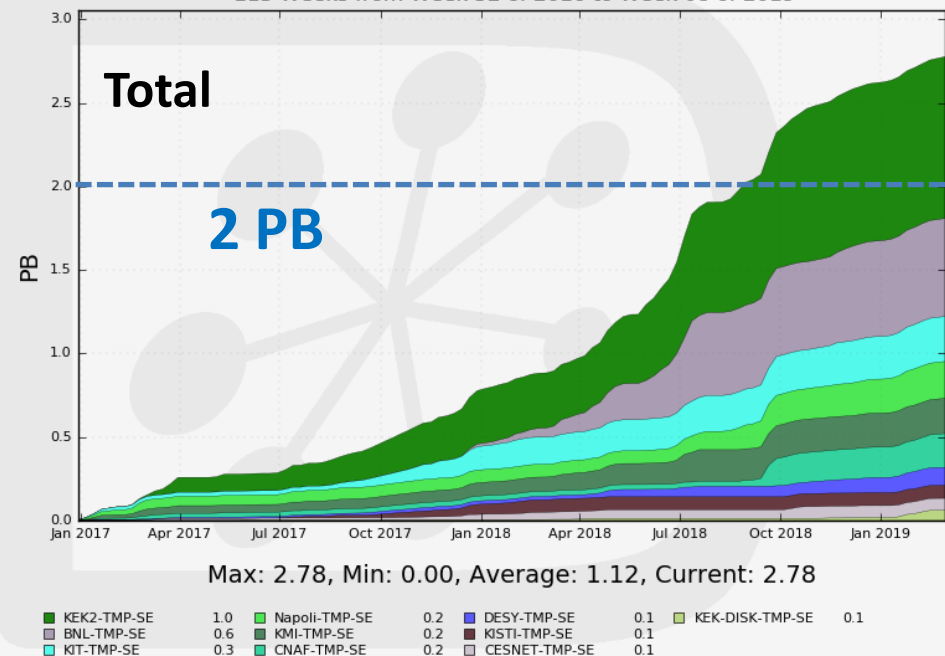
Throughput by Destination

113 Weeks from Week 52 of 2016 to Week 08 of 2019



Transferred data by Destination

113 Weeks from Week 52 of 2016 to Week 08 of 2019



- Produced MC/data files are collected in “Primary SEs”
- 10 primary SEs (Asia:3, US:1, Europe: 6) among ~30 SEs.
- Replica creation/clearing/BG distribution **still in the manual basis**
Working on the automation.
 - Improvement of BelleDIRAC DDM
 - Implementation of Rucio into DIRAC

- Modular analysis with python steering file.

✓ Particle selection.

✓ Reconstruction with decay string

✓ Vertex fits, flavor tagging, continuum suppression ...

- Many re-discoveries **after a few weeks** of the first collision.
(including results from user who started analysis after first collision)

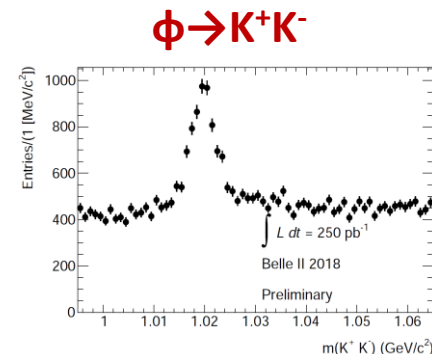
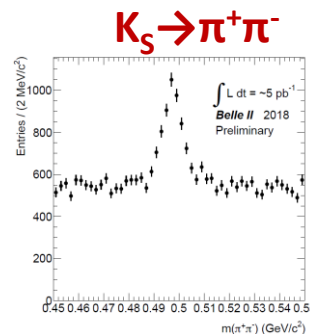
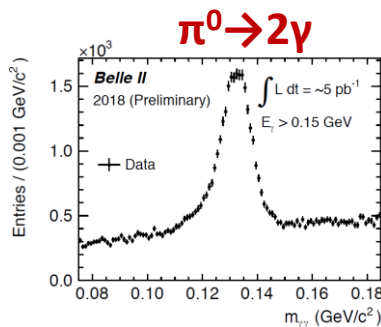
```
# create "mu+:loose" ParticleList (and c.c.)
stdLooseMu()

# create Ks -> pi+ pi- list from V0
# keep only candidates with 0.4 < M(pipi) < 0.6 GeV
fillParticleList('K_S0:pi pi', '0.4 < M < 0.6')

# reconstruct J/psi -> mu+ mu- decay
# keep only candidates with 3.0 < M(mumu) < 3.2 GeV
reconstructDecay('J/psi:mumu -> mu+:loose mu-:loose', '3.0 < M < 3.2')

# reconstruct B0 -> J/psi Ks decay
# keep only candidates with 5.2 < M(J/PsiKs) < 5.4 GeV
reconstructDecay('B0:jspi ks -> J/psi:mumu K_S0:pi pi', '5.2 < M < 5.4')

# perform B0 kinematic vertex fit using only the mu+ mu-
# keep candidates only passing C.L. value of the fit > 0.0 (no cut)
vertexRave('B0:jspi ks', 0.0, 'B0 -> [J/psi -> ^mu+ ^mu-] K_S0')
```

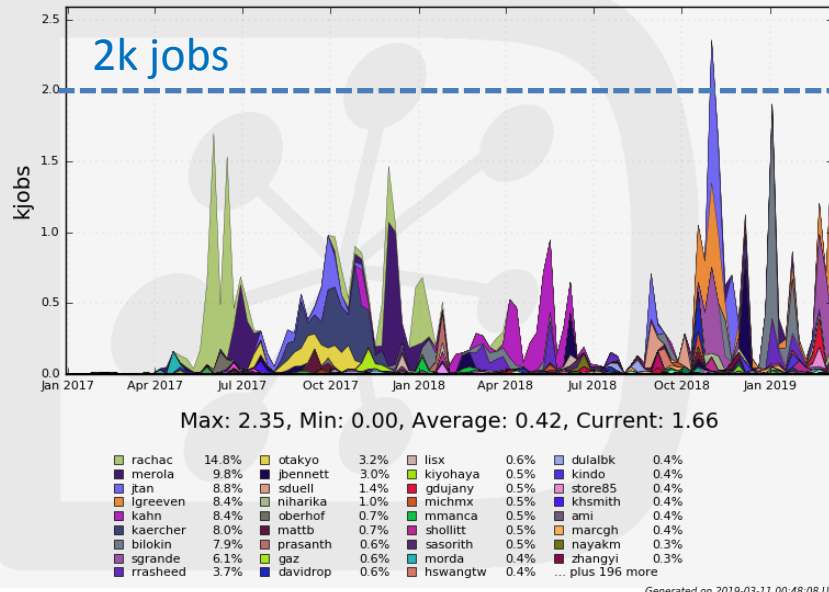


- Starterkit several times/year on a regular basis.



Running jobs by User

114 Weeks from Week 52 of 2016 to Week 09 of 2019



- Set of user analysis clients (gbasf2) are developed
 - Submission of job to grid/Check status
 - Download output files

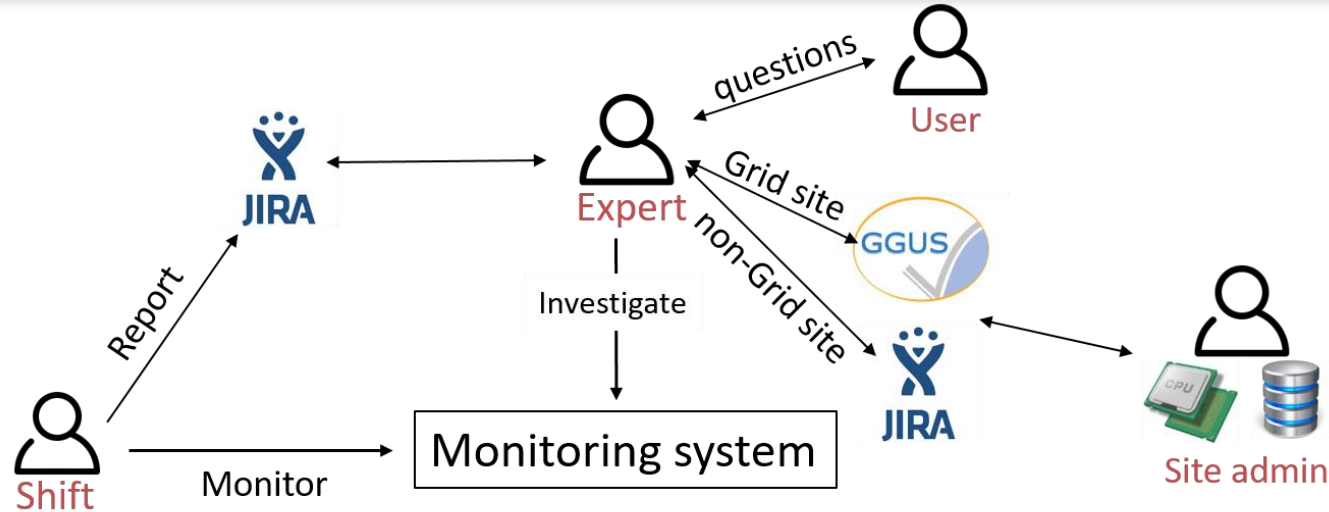
Local

```
%basf2 example.py -i input  
%gbasf2 example.py -i input -p project
```

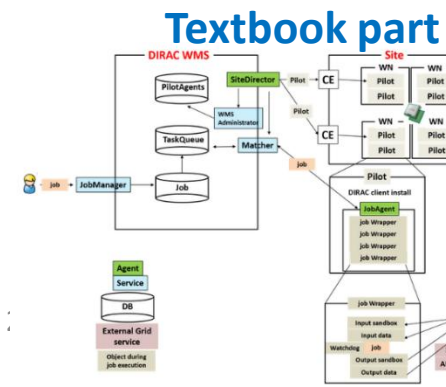
Grid

↓
Name for set of jobs

- Still several hundreds of jobs in average.
 - Approximately half of Belle II collaborators are registered on DIRAC
 - Approximately half of them have experience to submit jobs.
- Expected to increase with the start of data taking.



- ~2 JIRA tickets/day are submitted.
- 90% of expert slots are occupied by 5 members in 2018:
 - Difficult to continue 10 years operation.
 - Missing great opportunity for students to learn DC world.
- Development of training course.
- Automated JIRA/ggus submission under development



Quiz part

- Understand the workflow of pilot jobs.
- Understand the relation between pilot jobs and payload jobs.
- Read the Pilot log file.
- Write a jobID and its corresponding #siteReference (found in the leftmost column in the PilotHistory).
- What is the site name where this pilot job was executed?
- The hardware, which contains DIRAC/ReliDMS code/DIRAC-core/Job-Manager and "ReliDMS-WebJob-Manager", was taken from where?
- How many times is JobAgent executed in this pilot job?
- How many payload jobs were executed in this pilot job?
- What is the software release used for the first payload job?

- **Belle II has started!**
- Quick rediscoveries after the first collisions proved **software is ready.**
- Computing is stably working.
 - ~20000 jobs, 100 MB/s
- Need efforts for **long term** operation
 - Automatization (data operation/monitoring)
 - Increase operation man power

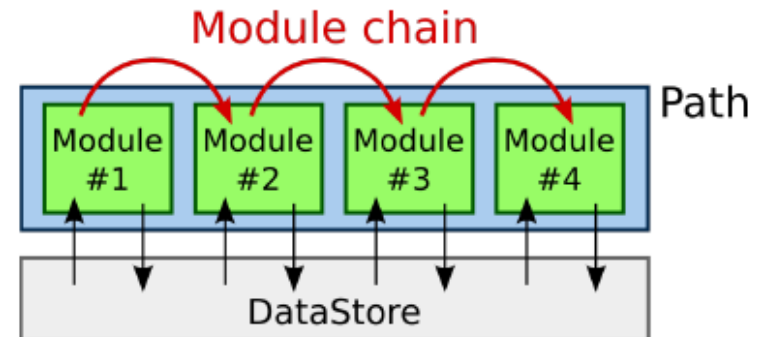
Keep growing to find NP from flavor sector.

Backup

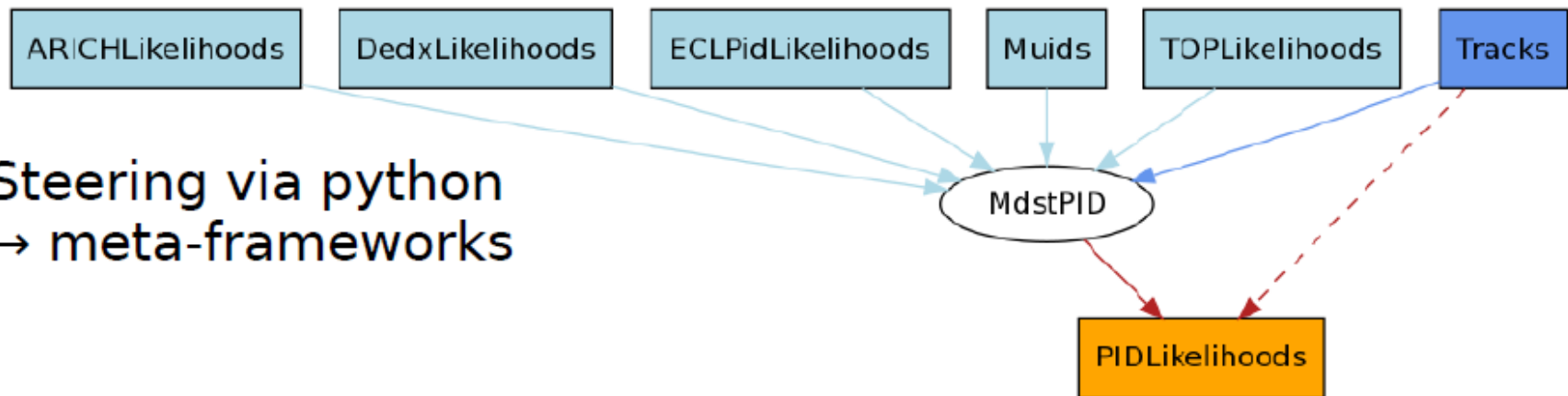
Software Framework: basf2

→ Thomas Hauth: PyHEP

- Used online and offline
- Dynamic loading of modules
- Data exchange via DataStore
- Relations
- Root I/O
- Belle data input (b2bii)

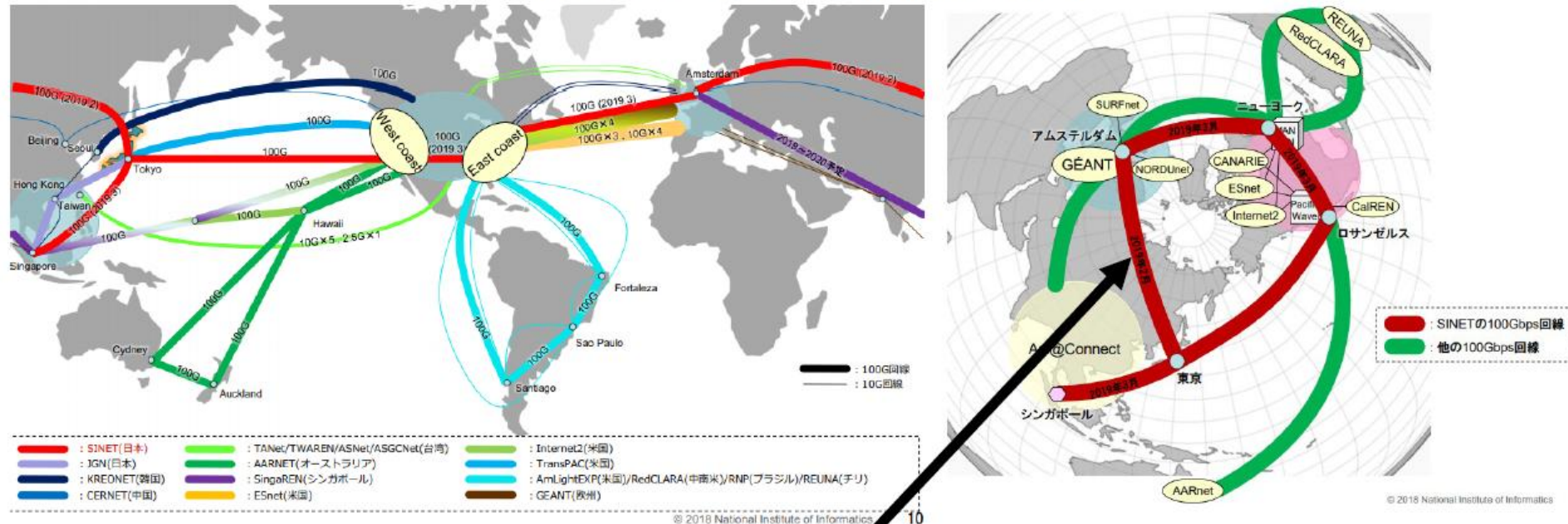


```
StoreArray<Track> tracks;  
for (const Track& track: tracks) {  
    const PIDLikelihood* pid =  
        track->getRelated<PIDLikelihood>();  
}
```



- Steering via python
→ meta-frameworks

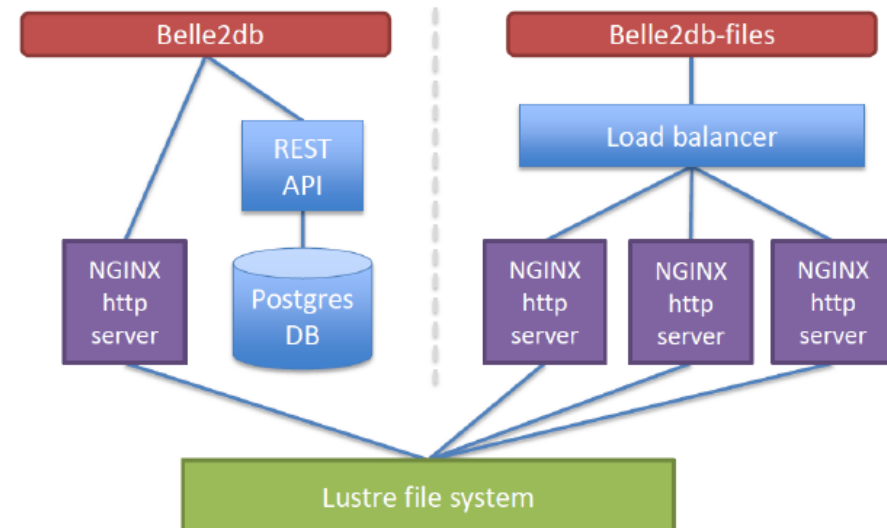
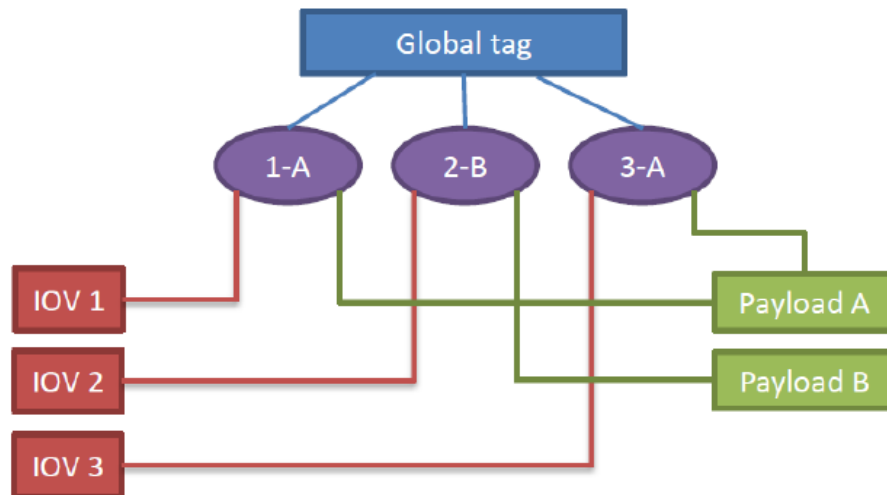
100G UPGRADE



- JP-EU link upgrade from 2x10G to 1x100G -Feb. 2019 (Tokyo to Amsterdam on NetherLight + L3 Peering GEANT-SINET)
- JP-NY link replaced by LA-NY 100G link . March 2019
- New Trans-Atlantic NY-EU 100G March 2019 : <https://kds.kek.jp/indico/event/28721/contribution/2/material/slides/0.pdf>
: https://www.nii.ac.jp/service/upload/1_meeting2018_sinet_20181029.pdf

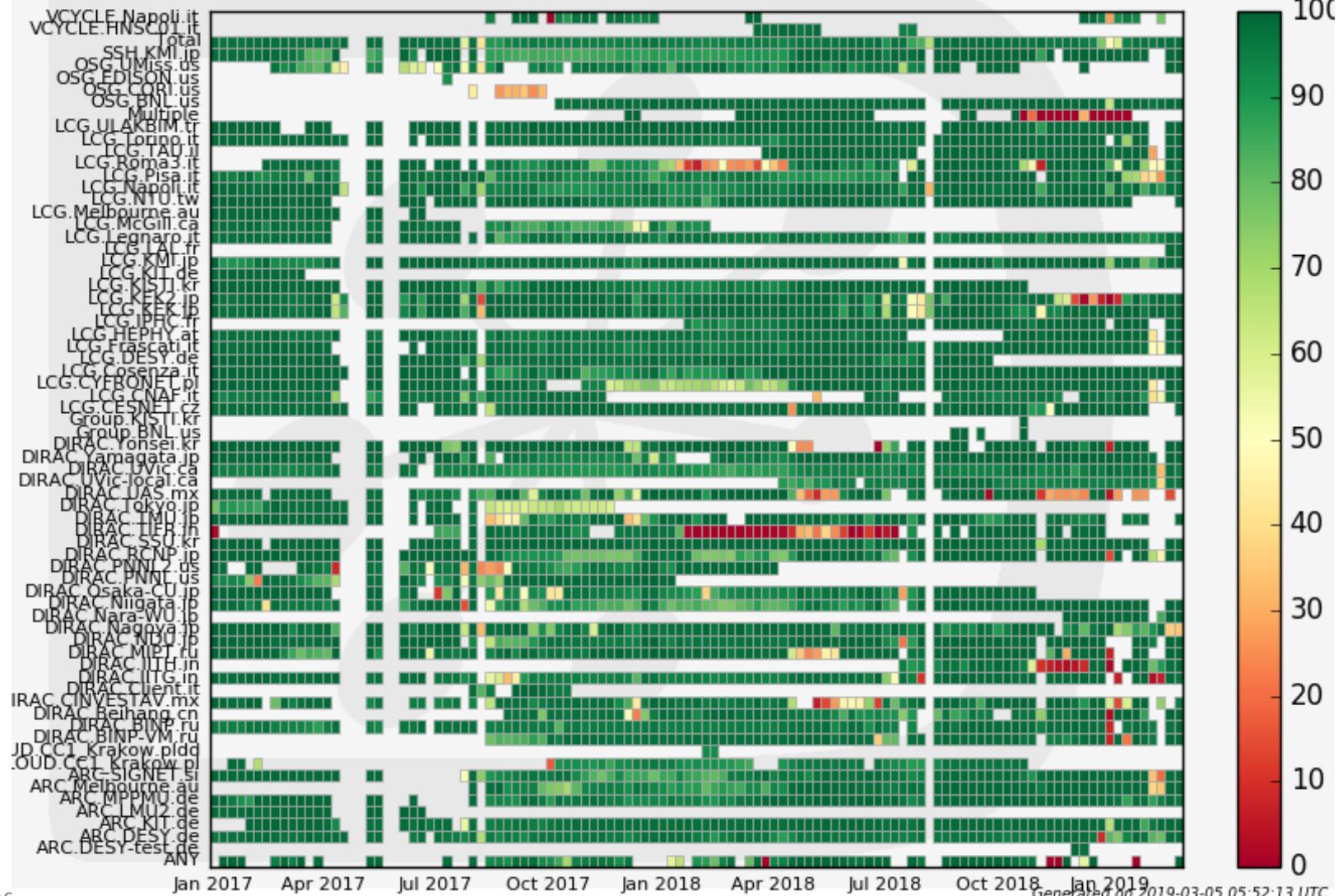
- User interface similar to DataStore interface
- Global tag: Assignments of intervals of validity (IoV) to payloads → Database
- Conditions data stored in objects in root files (payloads) → Provided via CVMFS or downloaded from server

```
DBObjPtr<BeamParameters> beams;  
double E = beams->getEnergy();
```



Job CPU efficiency by Site

113 Weeks from Week 52 of 2016 to Week 08 of 2019



DC central system

- DIRAC main servers are hosted by KEK
 - Data transfer (DDM) and major development servers are hosted by BNL

