



# Belle II Network Performance Analysis in the Context of the WLCG Data Challenge 2024

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## INTRODUCTION

The Belle II experiment relies on a distributed computing infrastructure spanning 19 countries and over 58 sites. It is expected to generate approximately **40TB/day** of raw data in 2027, necessitating distribution from the High Energy Accelerator Research Organization (KEK) in Japan to six Data Centers across the USA, Europe, and Canada. Establishing a high-quality network has been a priority since 2012 to address the challenge of transferring data across long distances in high-latency environments.

In February 2024 Belle II joined the WLCG Data Challenge, performed together with LHC experiments with the goal to test network performance under stress, particularly due to the anticipated increase in traffic from the experiments with the High Luminosity LHC program at CERN.

## DATA CHALLENGE DATA AND TOOLS

For the test we created a synthetic dataset composed by 8.000 file of 5GB each, stored at KEK and reused multiple times for transfers.

All transfers have been done using DAVS protocol and the RUCIO+FTS production infrastructure.

Test automation has been done via a Python script that it operates on a cyclical base as follow:

- At each cycle, the script checks for existing replication rules associated with specific datasets.
- If no rule is found for a particular site, it verifies the presence of data replicas at that site.
- If replicas are absent, a new replication rule is created.
- When a replication rule exists but the replication is completed, the script triggers a deletion instruction.

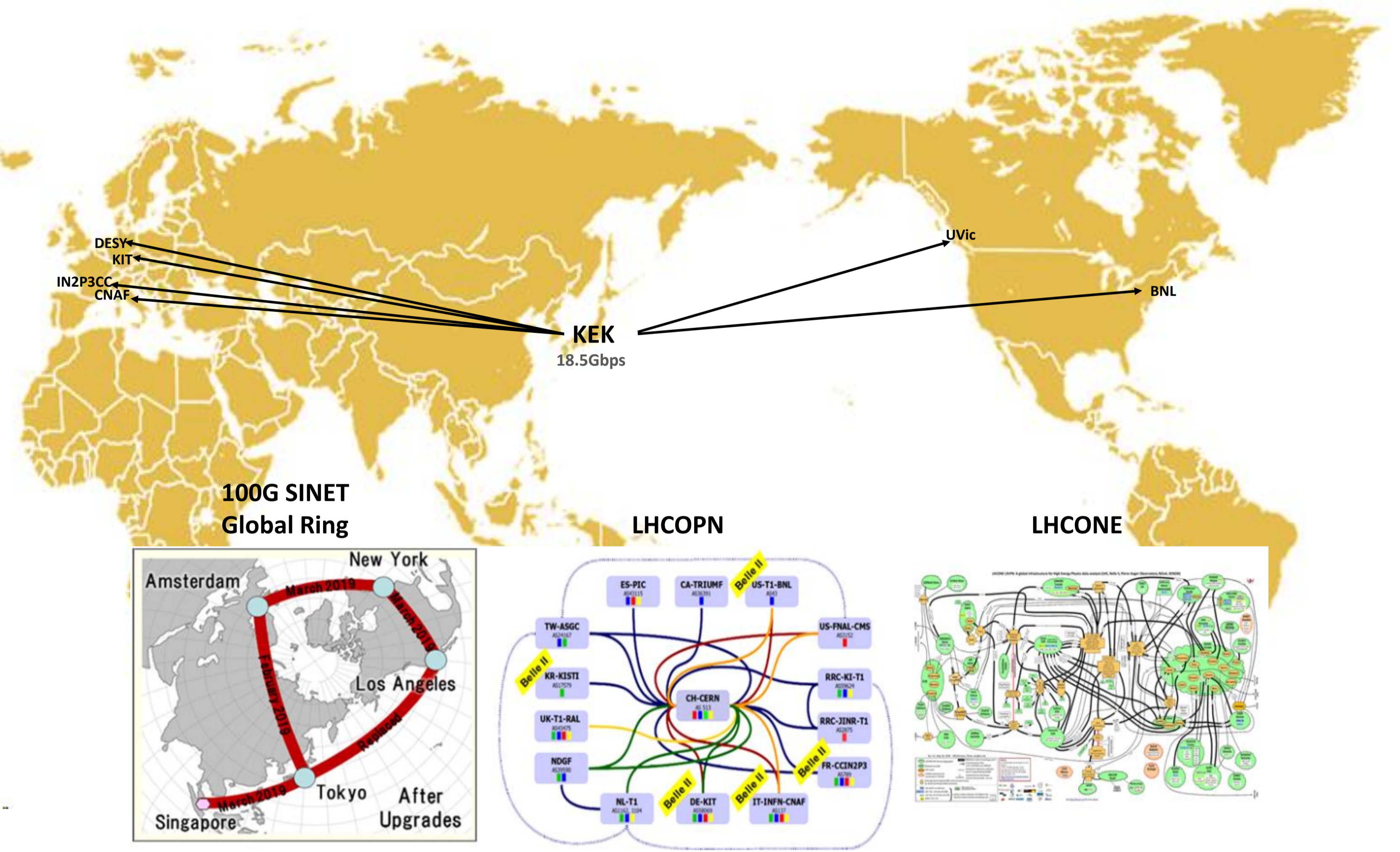
## Belle II Data Challenge Goals

### Main goal: Emulate RAW data copy in a Belle II future scenario

Considering that the average speed needed to transfer 40TB/day is 3.7Gbit/s in outbound at KEK vs all the Raw Data Centers.

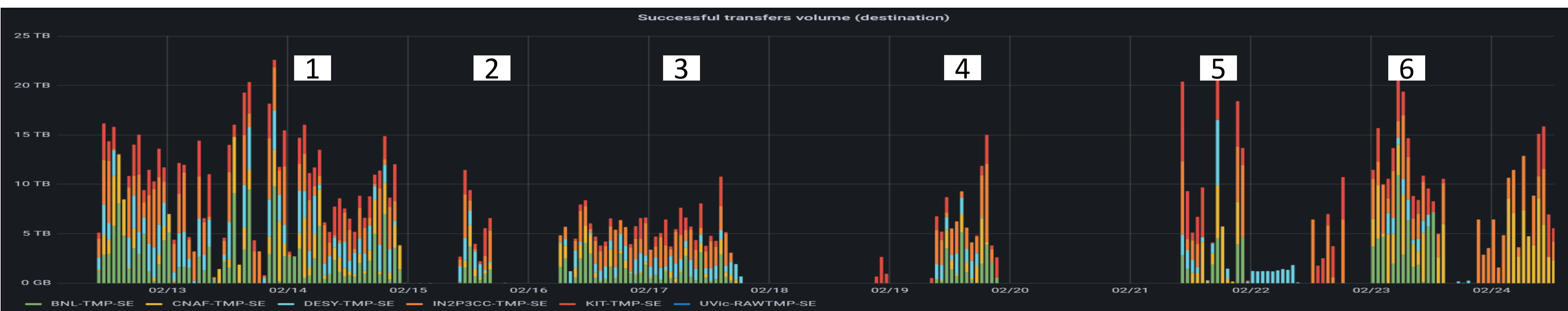
Transfers from KEK to RAW Data Centers according to our distribution schema (30%BNL, 20%CNAF, 15% IN2P3CC, 15%UVic, 10%DESY, 10%KIT)

- Min - The target speed to achieve is  $3 \times 3.7 \text{ Gbit/s} = 11.1 \text{ Gbit/s}$
- Max - The target speed to achieve is  $5 \times 3.7 \text{ Gbit/s} = 18.5 \text{ Gbit/s}$



	DATE	Test	TOT	Peak (1h)	Average
1	12/02/2024 9:00 to 14/02/2024 23:00	KEK vs RAW DC (kek2-fts03 - v3.12.1)	606 TB/61h	50 Gbps	22,0 Gbps - Reached Max goal
2	15/02/2024 9:00 to 15/02/2024 16:00	KEK vs RAW DC (kek2-fts01 older)	39,9 TB/7h	25 Gbps	12,6 Gbps - Reached Min goal
3	16/02/2024 6:00 to 17/02/2024 19:00	KEK vs RAW DC (kek2-fts01)	194 TB/38h	24 Gbps	11,3 Gbps - Reached Min goal
4	19/02/2024 8:30 to 19/02/2024 21:30	KEK vs RAW DC + RAW DCs vs RAW DCs	80 TB/13h	27 Gbps	13,7 Gbps - Mixed traffic
5	21/02/2024 10:00 to 22/02/2024 9:00	RAW DCs vs RAW DCs (kek2-fts03)	141 TB/23h	46 Gbps	13,6 Gbps - Mixed traffic
6	23/02/2024 0:00 to 23/02/2024 14:00	KEK vs RAW DCs (kek2-fts03)	178 TB/15h	46 Gbps	26 Gbps - Reached Max goal

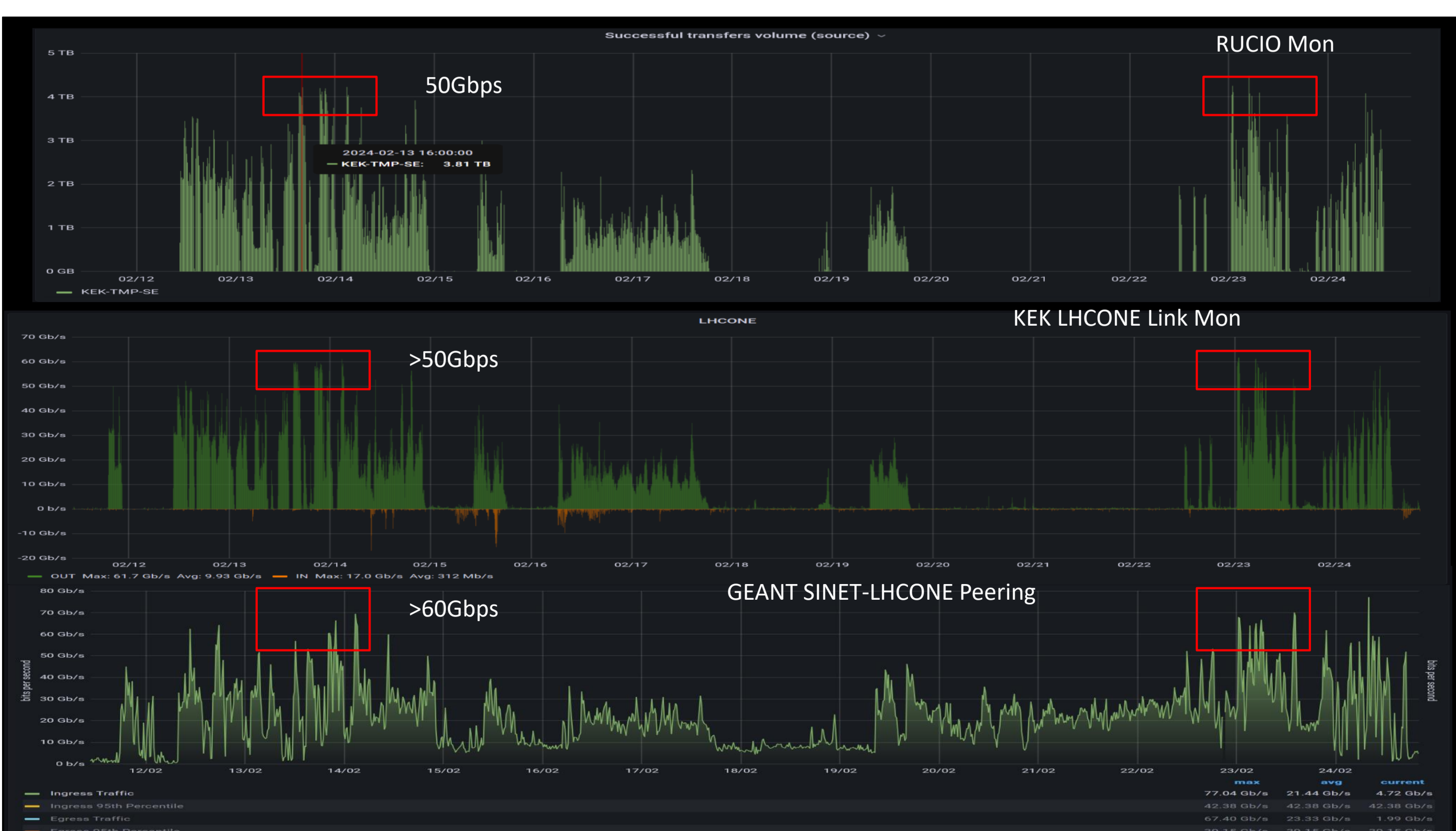
Belle II Data Challenge tests have been performed concurrently with the tests conducted by LHC experiments and DUNE. The table on the left shows the six time slots in which the synthetic data were copied from KEK to the Raw Data Centers (RAW DCs).



The graph on the left shows the data volume transferred per site. Data are collected through the Grafana dashboard of the Rucio monitoring system. Test number 6 was performed during the time windows in which LHC experiments pushed to the maximum, reaching the target of the flexible model.

Measuring the throughput from different points of observation allows us to confirm the results measured with the Rucio Monitoring system. The three graphs below show, respectively:

1. The network traffic seen through Rucio in outbound from KEK.
2. The traffic in outbound from the monitoring of the KEK LHCONE Network Link.
3. The traffic on the LHCONE peering between GEANT and SINET.



The graph above summarizes the total volume sent per day by RAW DCs during the two weeks of testing. It highlights that Belle II has reached its maximum target (>18.6 Gbps outbound from KEK) multiple times, coinciding with the periods when LHC experiments were testing their most intensive scenario, known as the 'flexible mode'.