



# Belle II update

Dr. Silvio Pardi

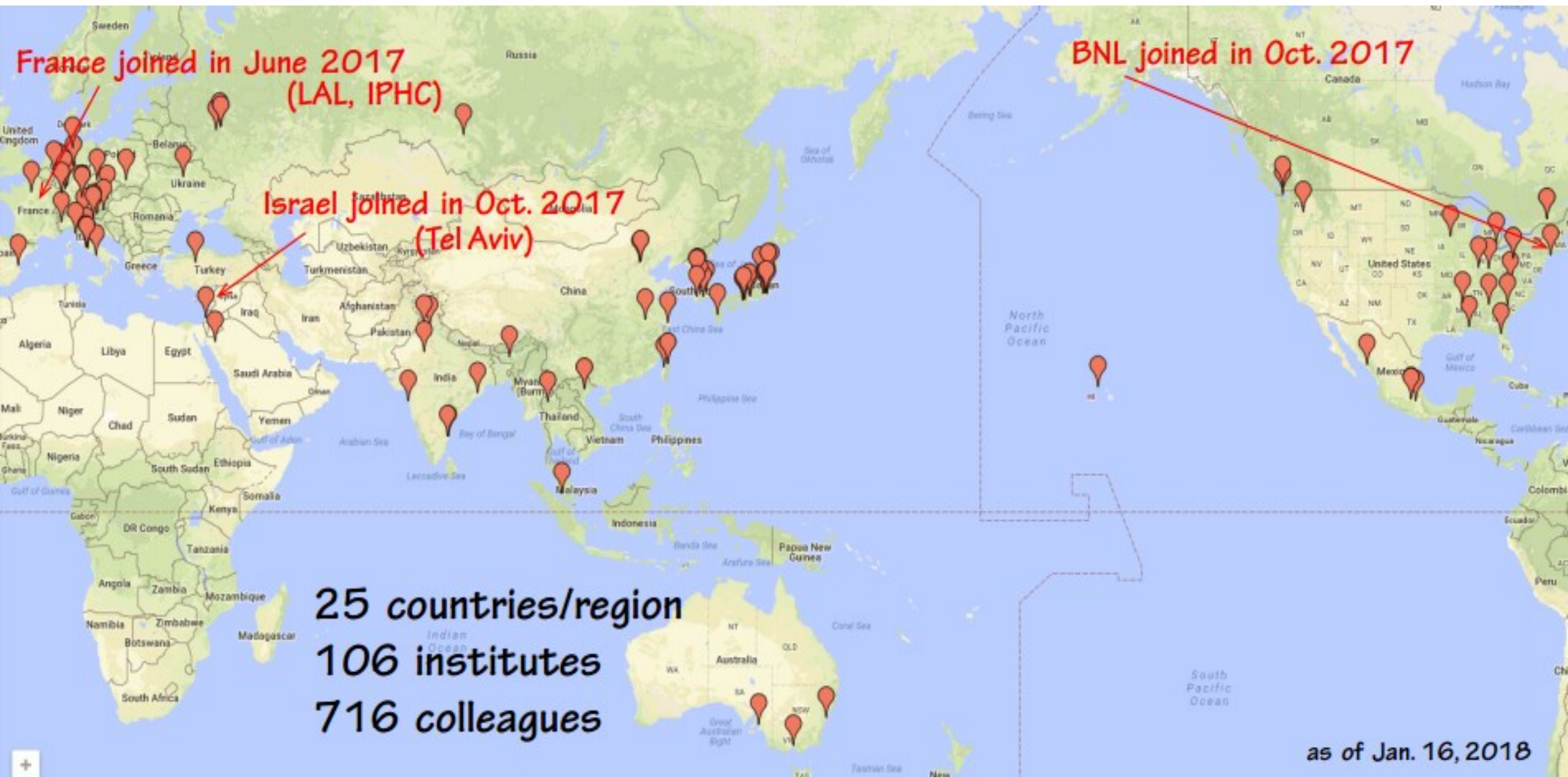
INFN-Napoli

**LHCOPN-LHCONE meeting**

6 March 2018



# THE BELLE II COLLABORATION



France joined in June 2017  
(LAL, IPHC)

Israel joined in Oct. 2017  
(Tel Aviv)

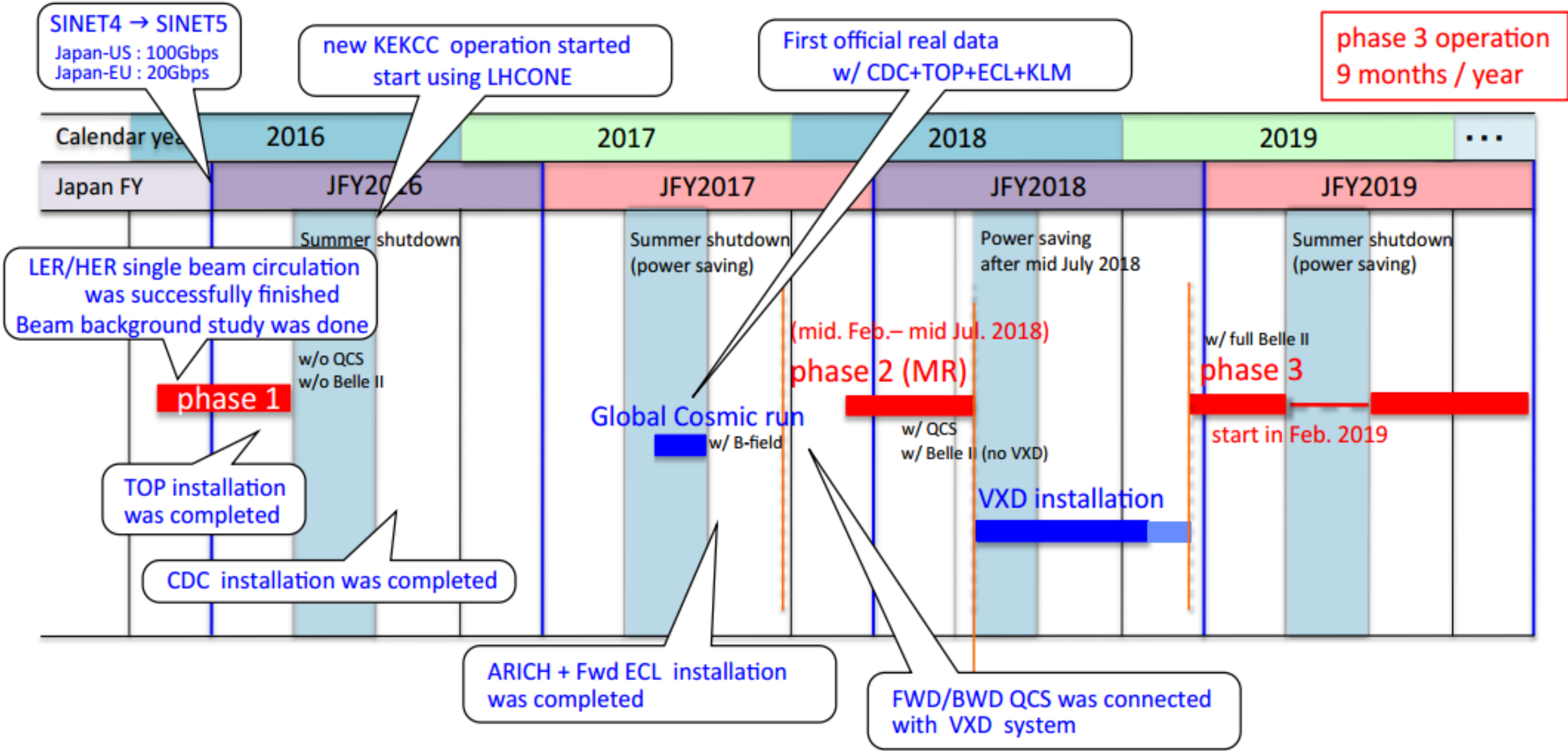
BNL joined in Oct. 2017

25 countries/region  
106 institutes  
716 colleagues

as of Jan. 16, 2018



# Belle II Experiment : Time line





# Network connectivity and LHCONE routing

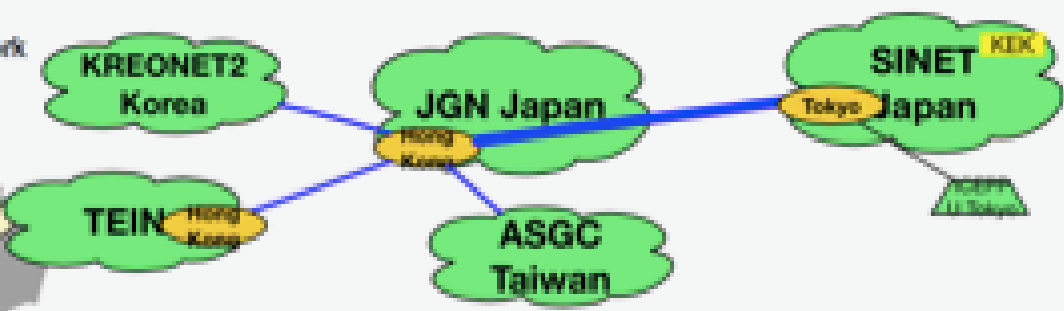
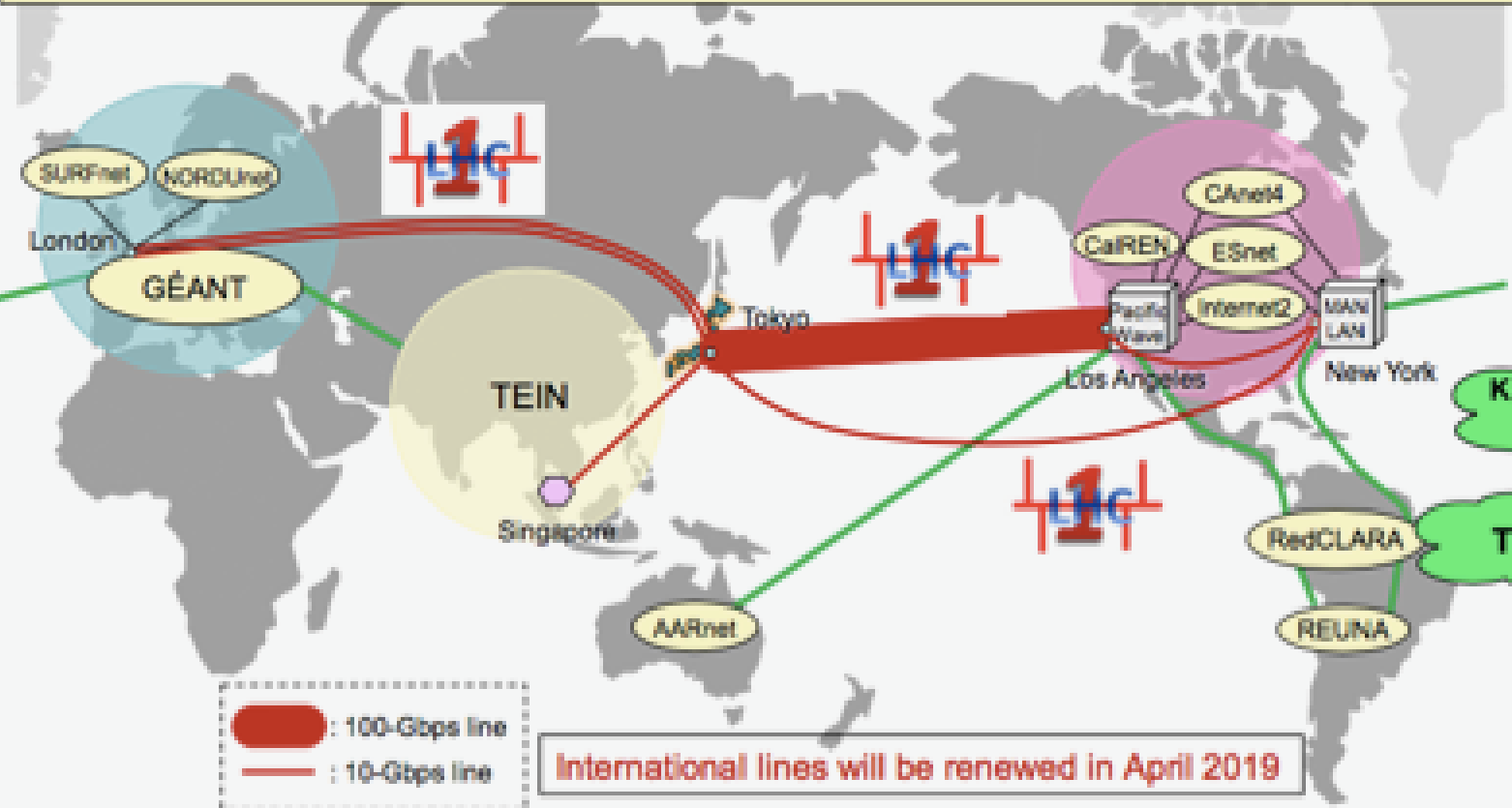
- ◆ SINET5 has direct international lines to USA, Europe, and Asia.
  - USA: 100-Gbps line to Los Angeles, 10-Gbps line to New York, and 10-Gbps backup line
  - Europe: Two 10-Gbps lines to London for small latency
  - Asia: 10-Gbps line to Singapore

T. Nakamura (KEKCRG) @ 28th B2GM on Oct 11, 2017

## LHCONE routing

Sep. 2016  
 GEANT at London (20G)  
 GEANT at NY (10G, backup)  
 ESnet, CANARIE at LA (100G)

Sep. 29th 2017  
 ASGC, KOREONET, (TEIN at Hong Kong (100G)

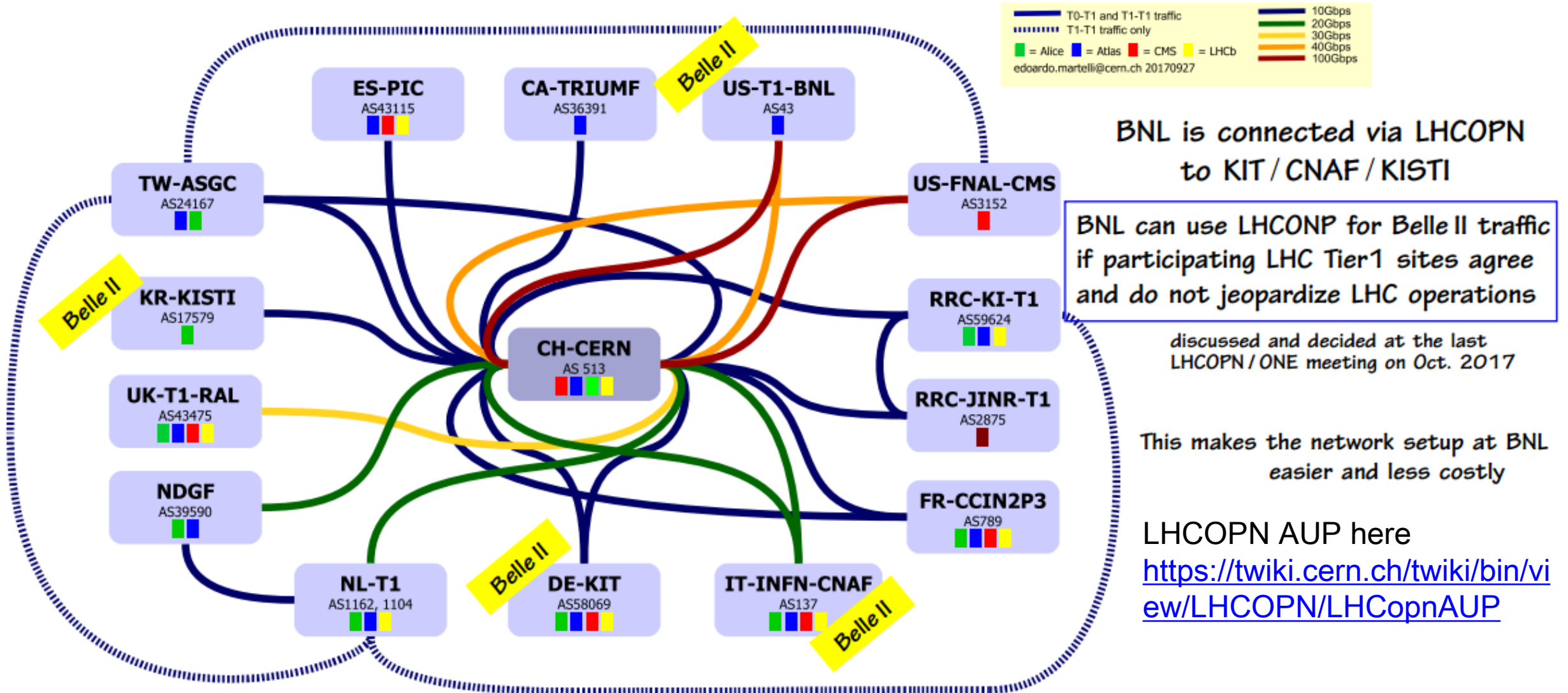


SINET International Links will be renewed in March 2019 for next period of 3 years.  
 EU link will be upgraded to 100G  
 NY link will be upgraded to 100G hopefully  
 SG link may be upgraded to 100G





# Belle II can utilize LHCOPN





# Network Estimation

- Estimate future Network requirements to support the Belle II computing model
  - MC Simulation
  - Raw data replication
  - Data Reconstruction
  - Skimming
  - Analysis
- Give feedbacks to Sites, NRENs and International Network Providers for planning purpose.
- Give information for Data challenge

**N.B. At present there are some uncertainties about the number of RAW data centers.**



# DATA FLOWS

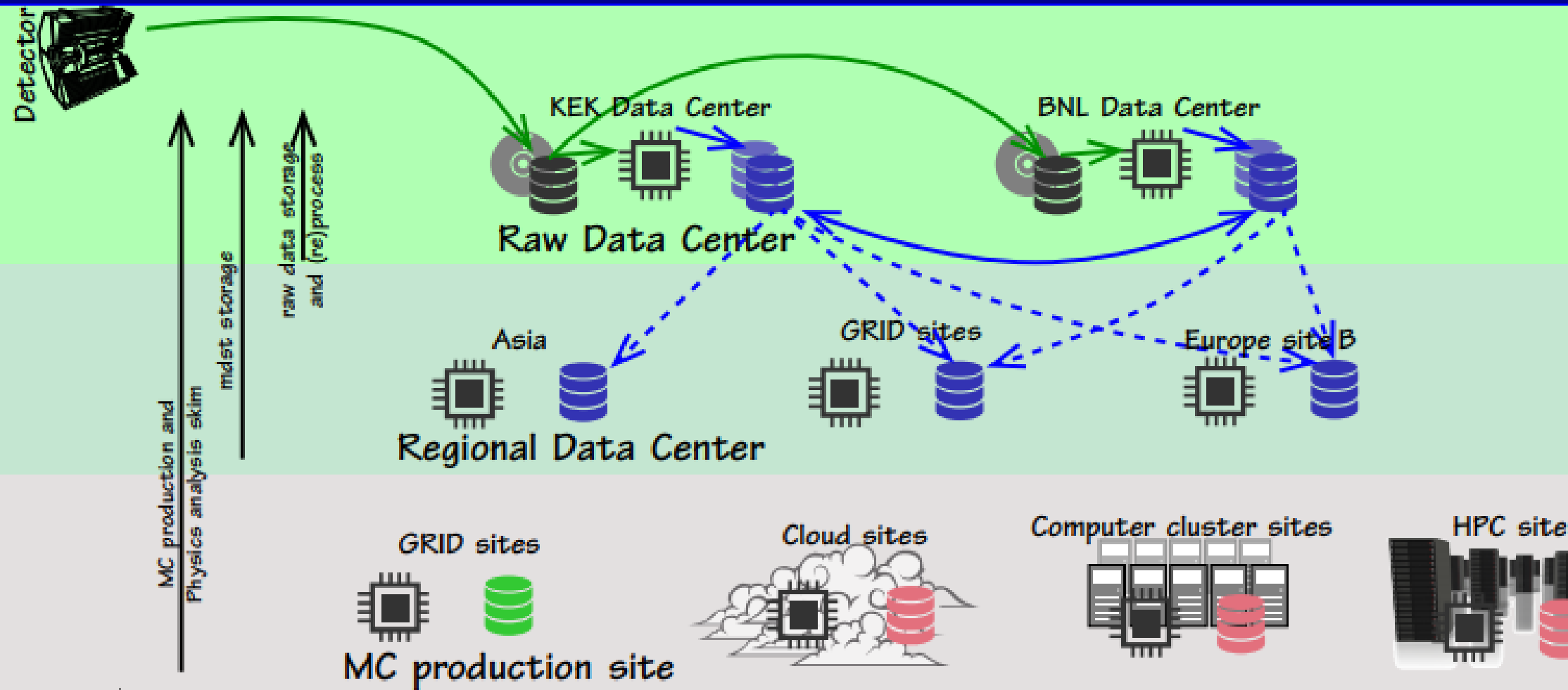
## 2 full copy for each data type

TYPE OF DATA	2018-2020	2021-2024
RAW Data Replication	100% BNL up to 2020.	BNL (30%) and other sites (some of the candidate countries: Italy, Germany, Canada, France, Korea, India)
MDST (Data Processing)	Produced at KEK and BNL and distributed over all sites	Produced at KEK, BNL and in all RAW data centers and then distributed over all sites.
Data Reprocessing	Produced at BNL and distributed over all sites up to 2020.	BNL and in all RAW data center and distributed over all sites.
Skimming	Produced by all sites and distributed over all sites. The amount of data stored in each site depend from the number of phd	
MC Reprocessing		
MC pre-Data Taking		
MC Data		
Analysis	Chaotic	



# Belle II Computing Model

RAW data + produced mdST  
end of year 3



	Raw data
	mdst D
	mdst M
	inputs for
	udst
	Ntuple
	CPU
	Disk
	Tape
	Storage for original + copy
	Storage for copy
	Temporary storage

MC production and Physics analysis skims  
 ↑  
 midst storage  
 ↑  
 raw data storage and (re)process

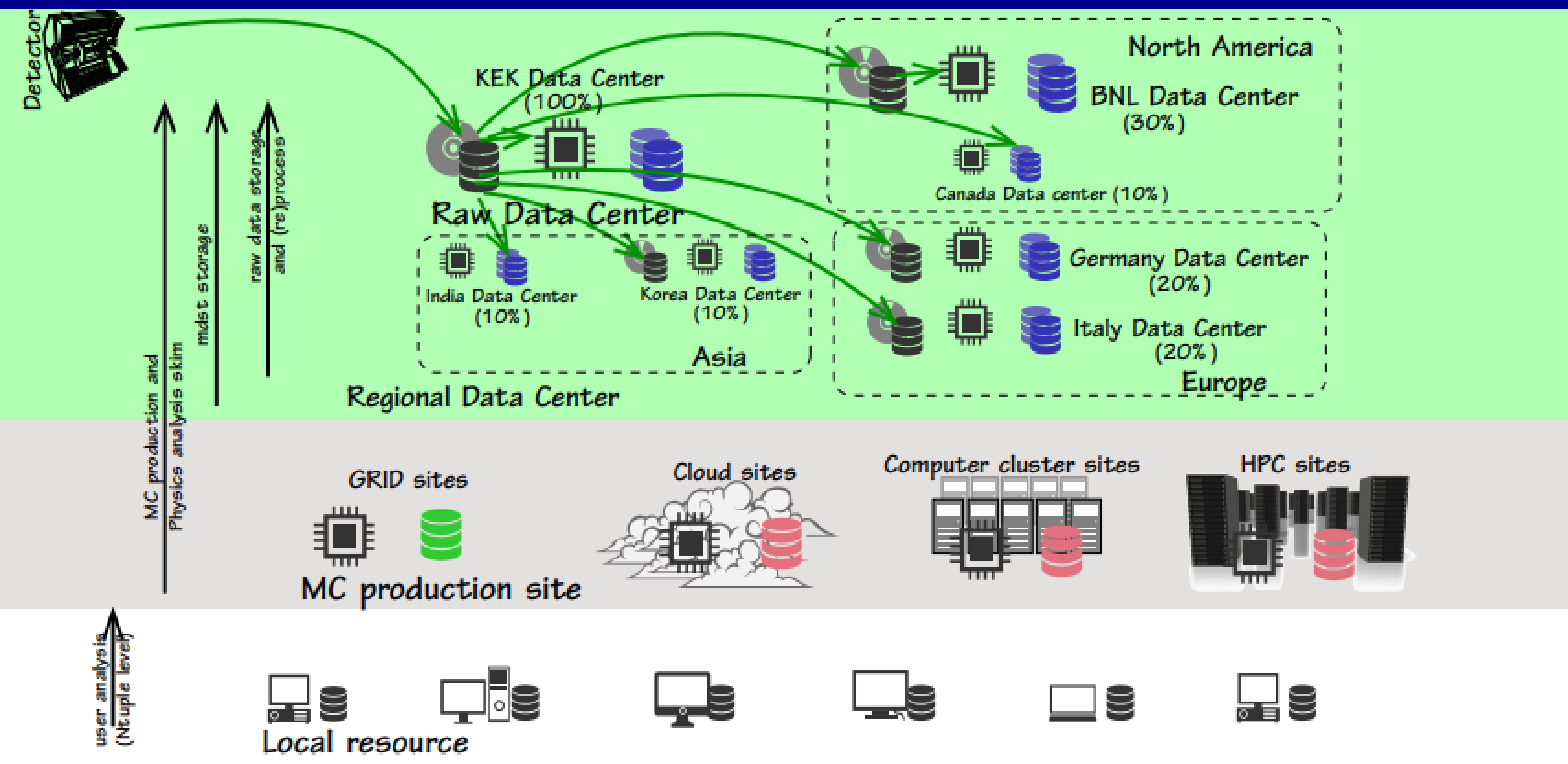
user analysis (Ntuple level)  
 ↑





# Belle II Computing Model

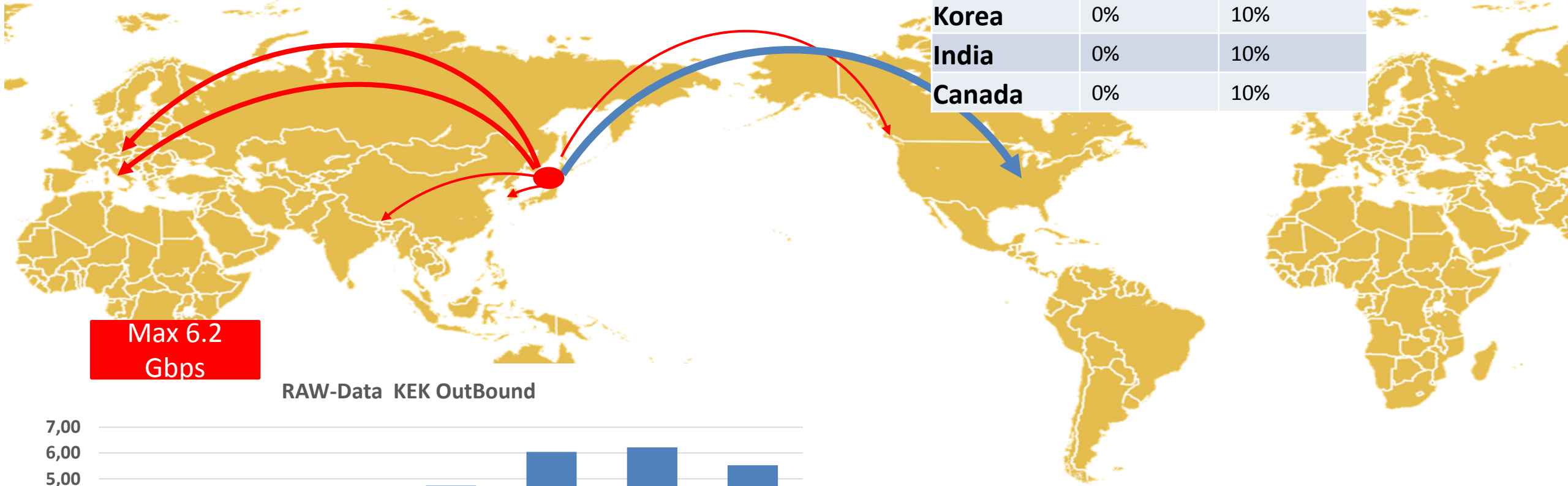
RAW data + produced mDST  
start year 4



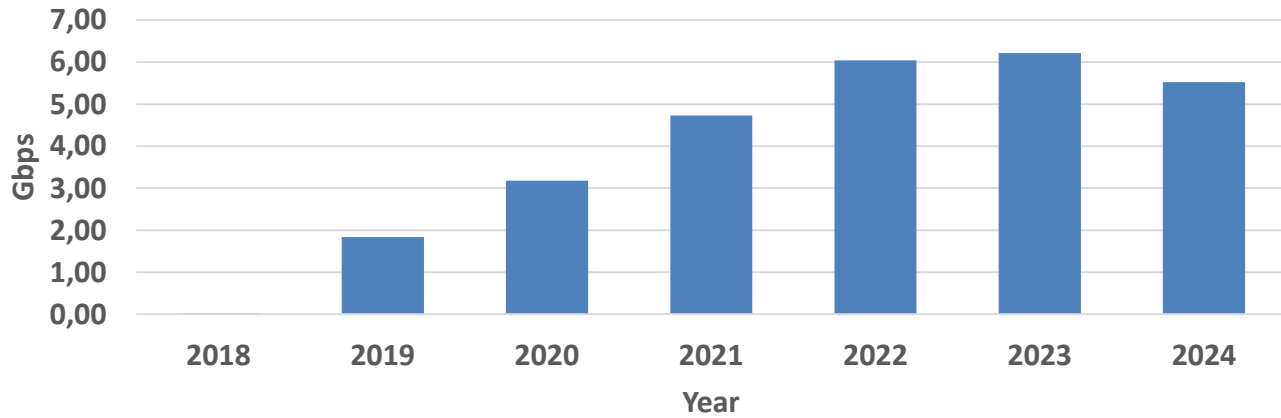


# 2° RAW Data Copy Replication Strategy

Year	2018- 2020	2021-2024
USA	100%	30%
Italy	0%	20%
Germany	0%	20%
Korea	0%	10%
India	0%	10%
Canada	0%	10%



RAW-Data KEK OutBound

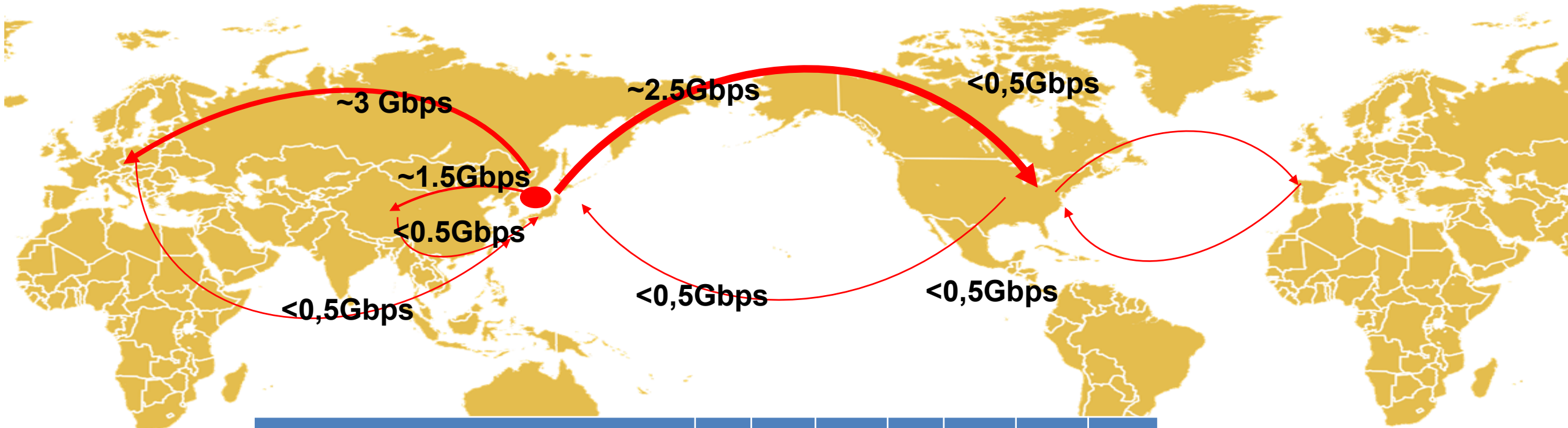






# Data Replication - Total Traffic per Regions

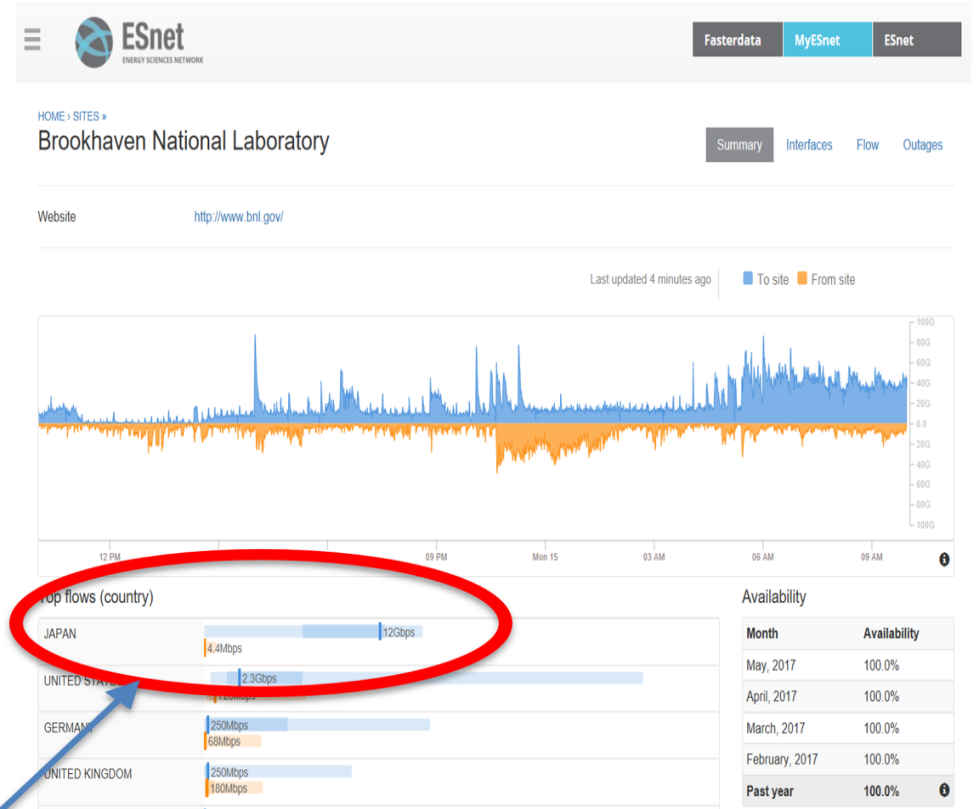
**N.B. USER ANALYSIS TRAFFIC NOT INCLUDED**



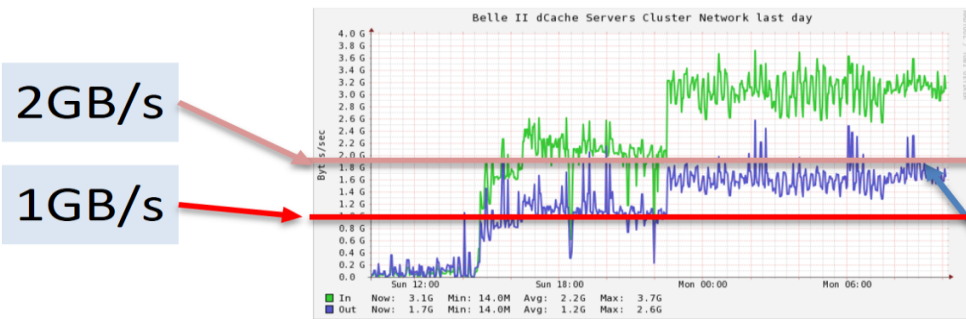
	2018	2019	2020	2021	2022	2023	2024
KEK to EU	0,20	0,11	0,16	2,10	2,70	2,86	2,64
KEK to USA+MEX+CANADA	0,11	1,88	3,25	1,99	2,54	2,65	2,40
KEK to ASIA	0,08	0,05	0,07	1,04	1,33	1,40	1,29
USA+MEX+CANADA to EU	0,17	0,14	0,19	0,16	0,21	0,35	0,41
EU to KEK	0,20	0,08	0,10	0,14	0,20	0,31	0,38
EU to USA+MEX+CANADA	0,17	0,07	0,09	0,12	0,17	0,27	0,33
USA+MEX+CANADA to KEK	0,09	0,07	0,10	0,08	0,11	0,18	0,21
ASIA to KEK	0,08	0,03	0,04	0,06	0,09	0,14	0,18

# Continuous Throughput Tests from KEK to BNL

- BNL has started the continuous network load test using BNL FTS.
- It was gradually increased from 400MB/s to 1.5GB/s.
- It achieved the sustained throughput at 1.5GBps in Jan 2018.



**2.3GBps achieved in new test in February**



Data rate from KEK to BNL Belle 12Gbps ~ 1.5GB/s



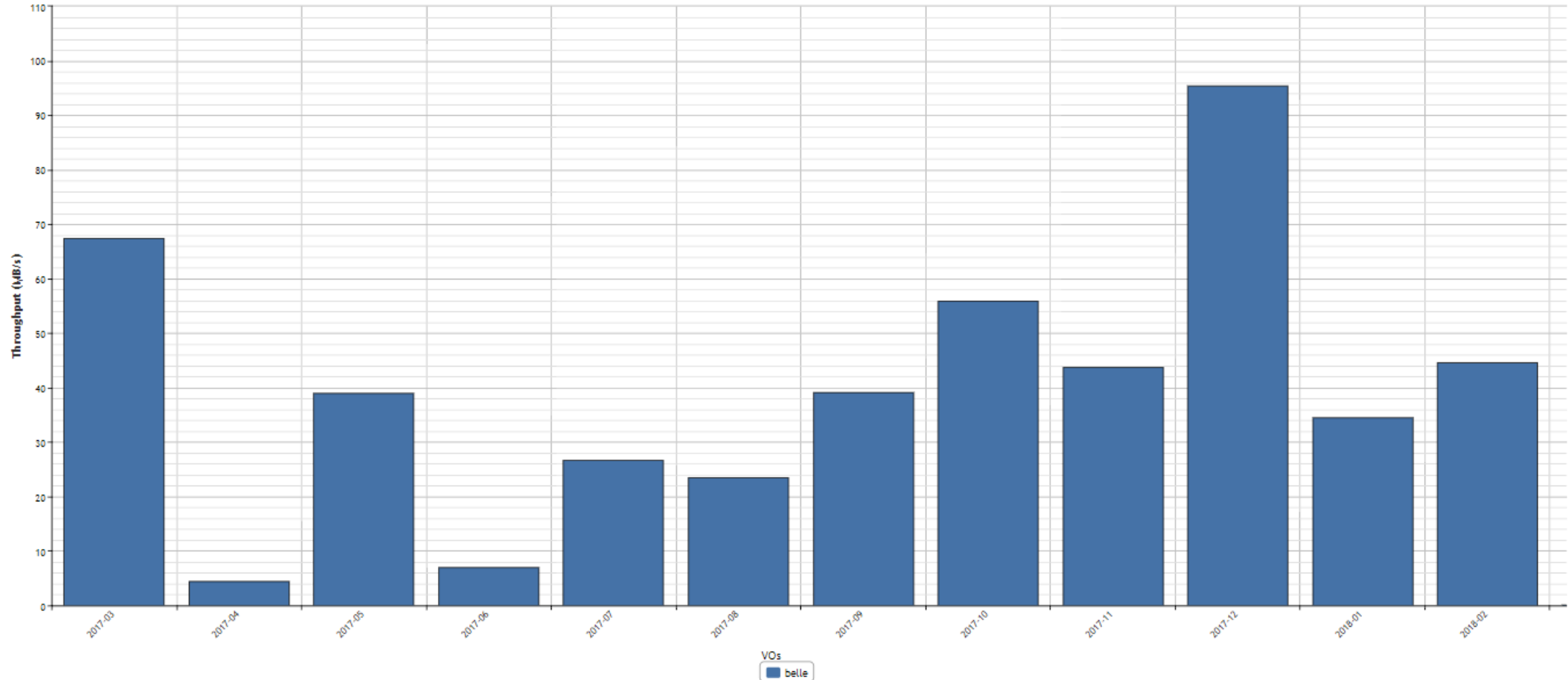


# FTS traffic in the last 12 months

dashboard

Throughput

2017-03-01 00:00 to 2018-03-05 00:00 UTC



**40MB/s average – peak of about 100MB/s**



# User Analysis and Skimming Traffic Preliminary Study

**After 1 year of User Analysis and Skimming on Grid is possible to do some statistic, extrapolate the NON-FTS traffic and try to predict it.**

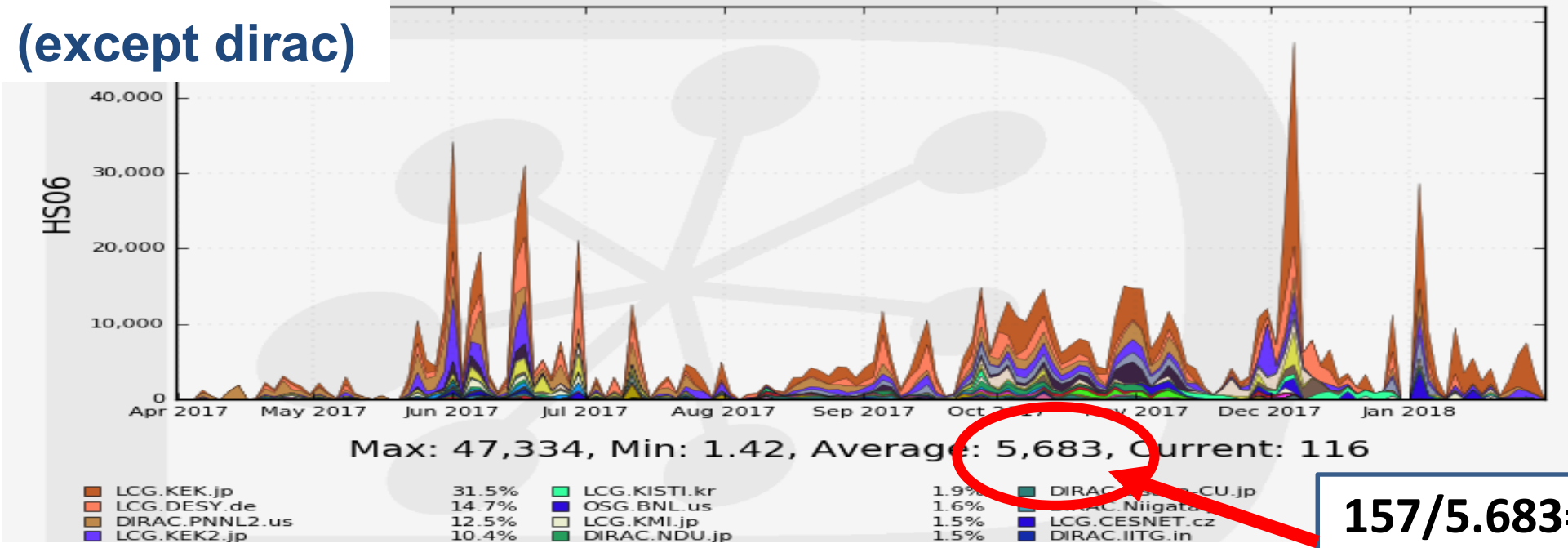
**N.B. Highly speculative activity.**

**At this stage some information may be missed or some assumptions maybe not 100% correct.**



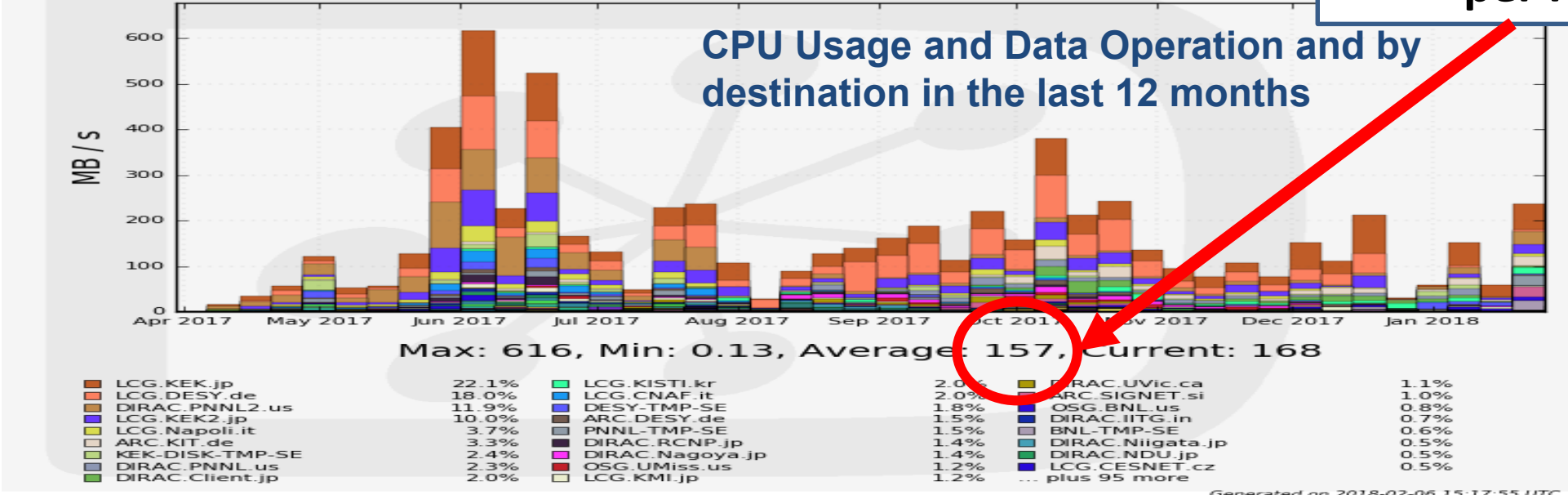
# All Users (except dirac)

Normalized CPU usage by Site  
43 Weeks from Week 13 of 2017 to Week 04 of 2018



**157/5.683=27.6 MB/s  
per KDB12**

Throughput by Destination  
43 Weeks from Week 13 of 2017 to Week 03 of 2018



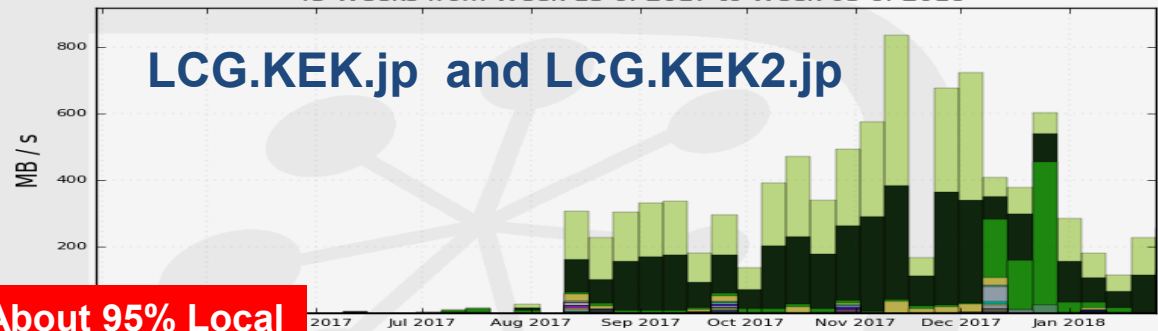
**CPU Usage and Data Operation and by destination in the last 12 months**



# External traffic analysis

Throughput by Source

43 Weeks from Week 13 of 2017 to Week 03 of 2018



LCG.KEK.jp and LCG.KEK2.jp

About 95% Local

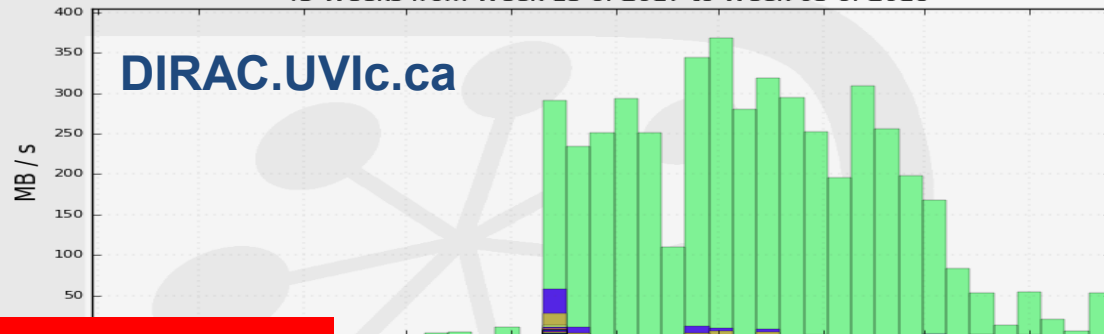
Max: 835, Min: 0.00, Average: 214, Current: 254

KEK-DISK-TMP-SE	42.9%	DESY-DATA-SE	0.1%	ULAKBIM-DATA-SE	0.1%	Napoli-TMP-SE	0.0%
KEK2-DATA-SE	41.0%	HEPHY-DATA-SE	0.1%	CYFRONET-DATA-SE	0.1%	IPHC-DATA-SE	0.0%
KEK2-TMP-SE	10.8%	McGill-DATA-SE	0.1%	Frascati-DATA-SE	0.1%	DESY-TMP-SE	0.0%
PNNL-DATA-SE	2.2%	BNL-TMP-SE	0.1%	Melbourne-DATA-SE	0.1%	Torino-DATA-SE	0.0%
KEK-TMP-SE	0.6%	Uvic-DATA-SE	0.1%	MPPMU-DATA-SE	0.1%	CNAF-DATA-SE	0.0%
BNL-DATA-SE	0.1%	KEK-DATA-SE	0.1%	Napoli-DATA-SE	0.0%	Adelaide-DATA-SE	0.0%
SIGNET-DATA-SE	0.1%	KIT-DATA-SE	0.1%	CESNET-DATA-SE	0.0%	KIT-TMP-SE	0.0%
KEK-FailoverSE	0.1%	KISTI-DATA-SE	0.1%	KMI-DATA-SE	0.0%	SIGNET-TMP-SE	0.0%
		NTU-DATA-SE	0.1%	Pisa-DATA-SE	0.0%	plus 15 more	

Generated on 2018-02-06 16:05:07 UTC

Throughput by Source

43 Weeks from Week 13 of 2017 to Week 03 of 2018



DIRAC.UVic.ca

About 98% Local

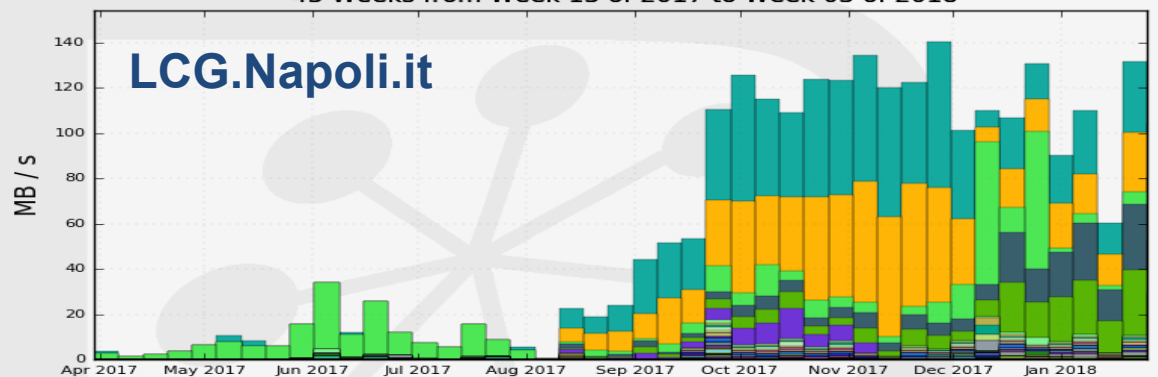
Max: 368, Average: 110, Current: 107

Uvic-DATA-SE	97.7%	KMI-TMP-SE	0.0%	KEK2-TMP-SE	0.0%	Adelaide-DATA-SE	0.0%
McGill-DATA-SE	1.2%	NAF-DATA-SE	0.0%	Melbourne-DATA-SE	0.0%	KEK-SandboxSE	0.0%
		ULAKBIM-DATA-SE	0.0%	CESNET-DATA-SE	0.0%	BNL-DATA-SE	0.0%
		KISTI-DATA-SE	0.0%	DESY-TMP-SE	0.0%	DESY-TMP-SE	0.0%
		KEK-DATA-SE	0.0%	Napoli-DATA-SE	0.0%	PNNL-TMP-SE	0.0%
		NTU-DATA-SE	0.0%	KMI-DATA-SE	0.0%	SIGNET-TMP-SE	0.0%
		SIGNET-DATA-SE	0.0%	CYFRONET-DATA-SE	0.0%	KEK-DISK-TMP-SE	0.0%
		IPHC-DATA-SE	0.0%	KEK2-DATA-SE	0.0%	KIT-TMP-SE	0.0%
		Frascati-DATA-SE	0.0%	Torino-DATA-SE	0.0%	CESNET-TMP-SE	0.0%
		plus 11 more				plus 11 more	

Generated on 2018-02-06 16:21:50 UTC

Throughput by Source

43 Weeks from Week 13 of 2017 to Week 03 of 2018



LCG.Napoli.it

Max: 140, Min: 0.39, Average: 58.3, Current: 105

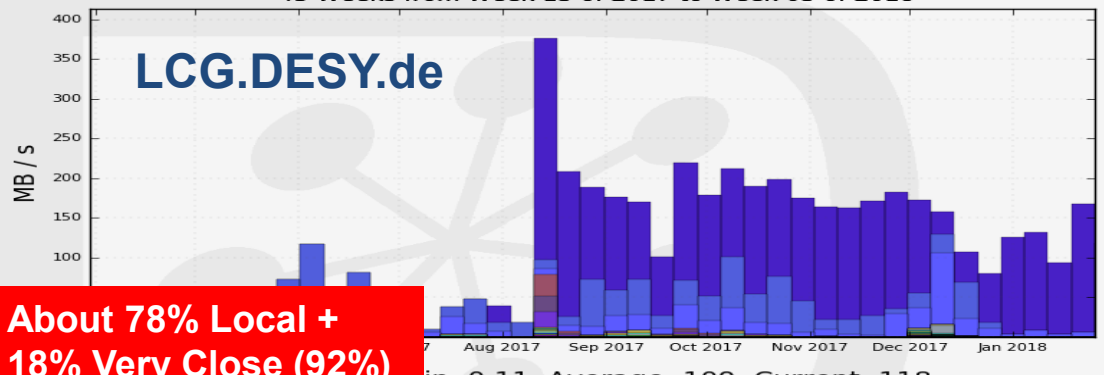
Napoli-DATA-SE	31.5%	SIGNET-DATA-SE	0.4%	DESY-DATA-SE	0.3%	CNAF-TMP-SE	0.1%
Pisa-DATA-SE	26.1%	IPHC-DATA-SE	0.3%	KMI-DATA-SE	0.2%	KIT-TMP-SE	0.0%
Napoli-TMP-SE	16.1%	CESNET-DATA-SE	0.3%	KEK2-DATA-SE	0.2%	KEK-DATA-SE	0.0%
Frascati-DATA-SE	8.5%	ULAKBIM-DATA-SE	0.3%	Adelaide-DATA-SE	0.2%	CESNET-TMP-SE	0.0%
Torino-DATA-SE	8.5%	PNNL-DATA-SE	0.5%	KEK-DISK-TMP-SE	0.2%	plus 14 more	
CNAF-DATA-SE	2.4%	BNL-DATA-SE	0.5%				
IPHC-DATA-SE	0.3%						
CESNET-DATA-SE	0.3%						
ULAKBIM-DATA-SE	0.3%						
PNNL-DATA-SE	0.5%						
BNL-DATA-SE	0.5%						

About 92.3% Local (Italian Tier Federation)

Generated on 2018-02-06 16:29:54 UTC

Throughput by Source

43 Weeks from Week 13 of 2017 to Week 03 of 2018



LCG.DESY.de

About 78% Local +  
18% Very Close (92%)

DESY-DATA-SE	64.5%	CESNET-TMP-SE	0.3%	Melbourne-DATA-SE	0.0%	IPHC-DATA-SE	0.0%
SIGNET-TMP-SE	18.7%	Napoli-TMP-SE	0.1%	Uvic-DATA-SE	0.0%	CESNET-DATA-SE	0.0%
DESY-TMP-SE	12.6%	KEK2-DATA-SE	0.1%	ULAKBIM-DATA-SE	0.0%	KEK2-TMP-SE	0.0%
KIT-DATA-SE	0.7%	HEPHY-DATA-SE	0.1%	NTU-DATA-SE	0.0%	BNL-TAPE-SE	0.0%
CNAF-DATA-SE	0.6%	KEK-SandboxSE	0.1%	CYFRONET-DATA-SE	0.0%	Pisa-DATA-SE	0.0%
PNNL-DATA-SE	0.5%	Adelaide-DATA-SE	0.0%	Adelaide-DATA-SE	0.0%	Torino-DATA-SE	0.0%
PNNL-TMP-SE	0.4%	KEK-DISK-TMP-SE	0.0%	Napoli-DATA-SE	0.0%	KMI-DATA-SE	0.0%
IPHC-DATA-SE	0.3%	SIGNET-DATA-SE	0.0%	Frascati-DATA-SE	0.0%	KMI-TMP-SE	0.0%
				KEK-DATA-SE	0.0%	plus 16 more	

Generated on 2018-02-06 16:20:34 UTC



# User Analysis traffic – Tentative prediction

## We Can Assume:

>92% of user traffic is Local

**<8% Geographic traffic**

User Traffic is correlated to the CPU usage. At now we have an average of 28MB/s (224Mbit/s) per KDB12.

CPU for User Analysis is expected to grow up to 167KDB12 in **2024**

**167\*224=37Gbit/s** -> **About 3 Gbit/s** of Geographic traffic produced by User Analysis that correspond to the 30% of the data movement traffic.

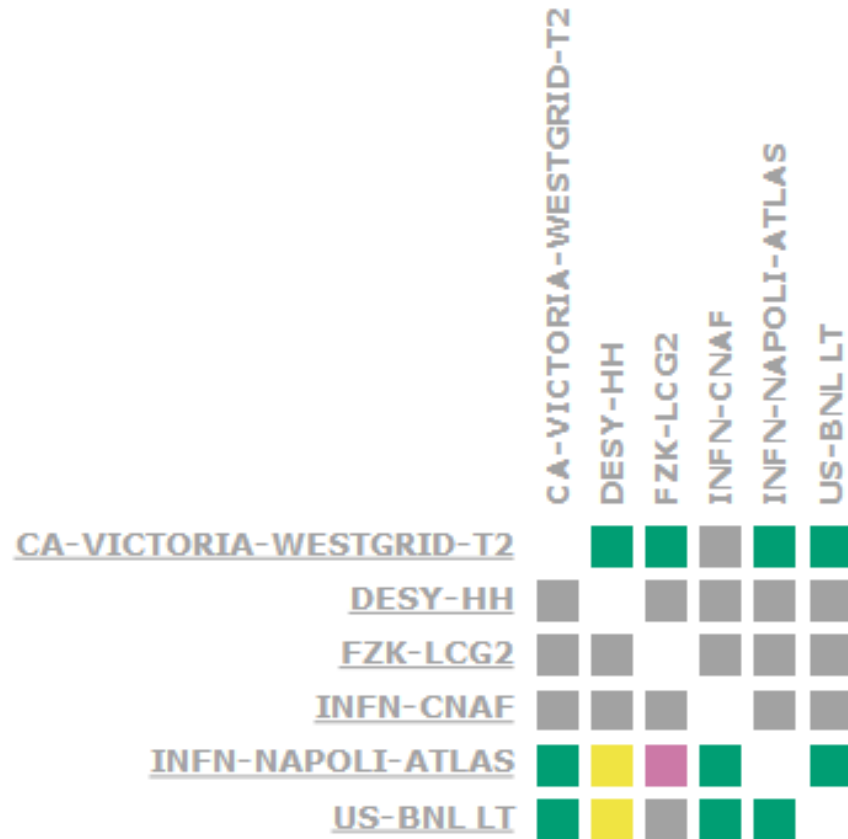




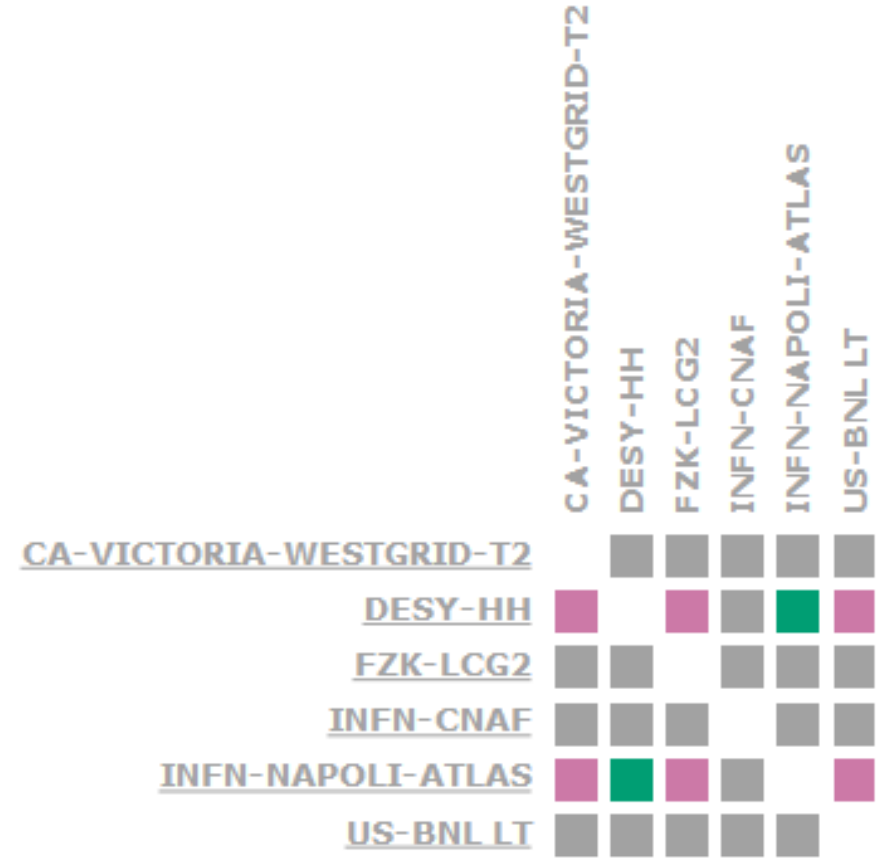


# Network Monitoring: IPv6 Mesh

## Belle II Latency mesh



## Belle II Bandwidth mesh



TESTING MESH



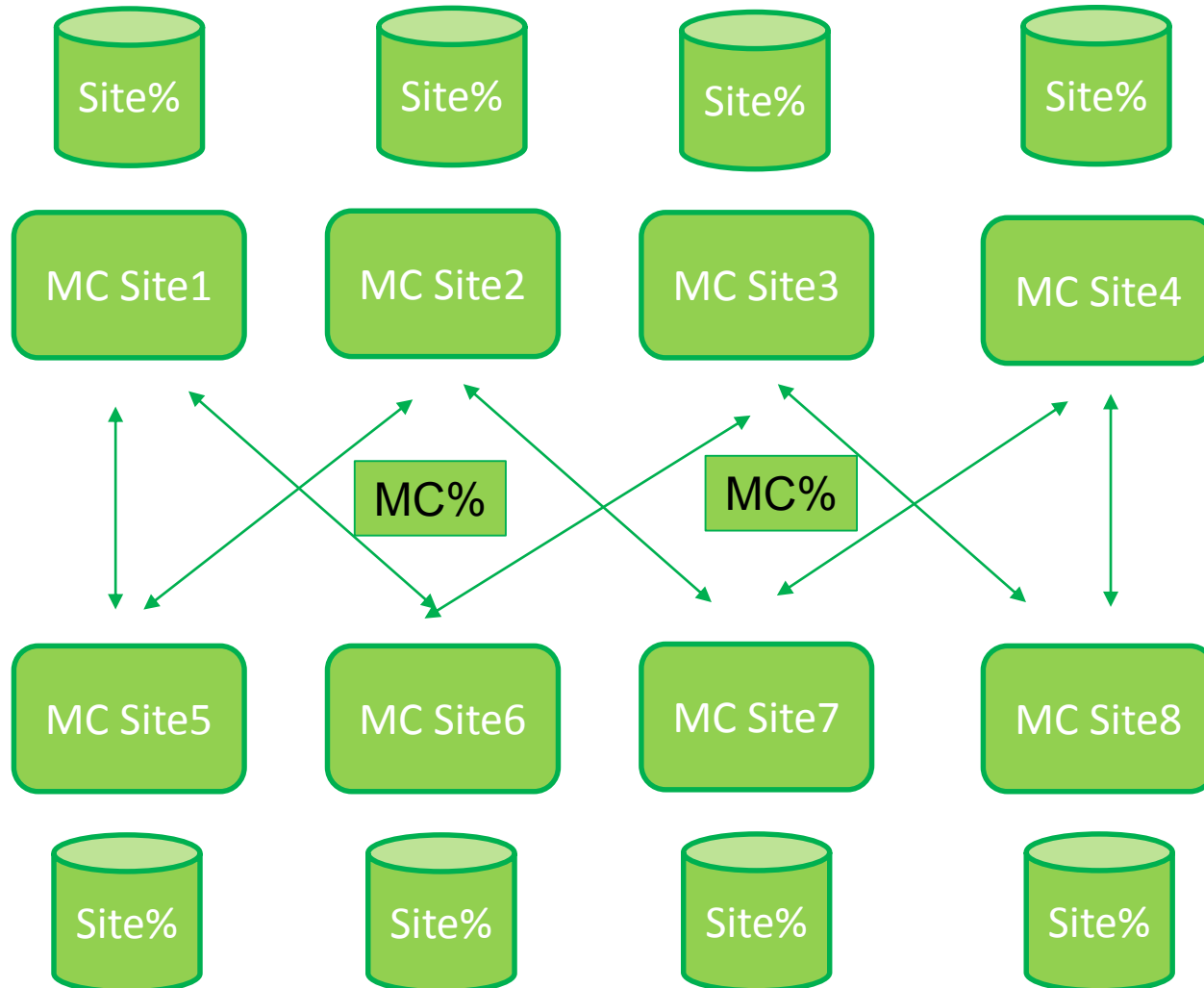
**BACKUP**



# Monte Carlo Production and Skimming

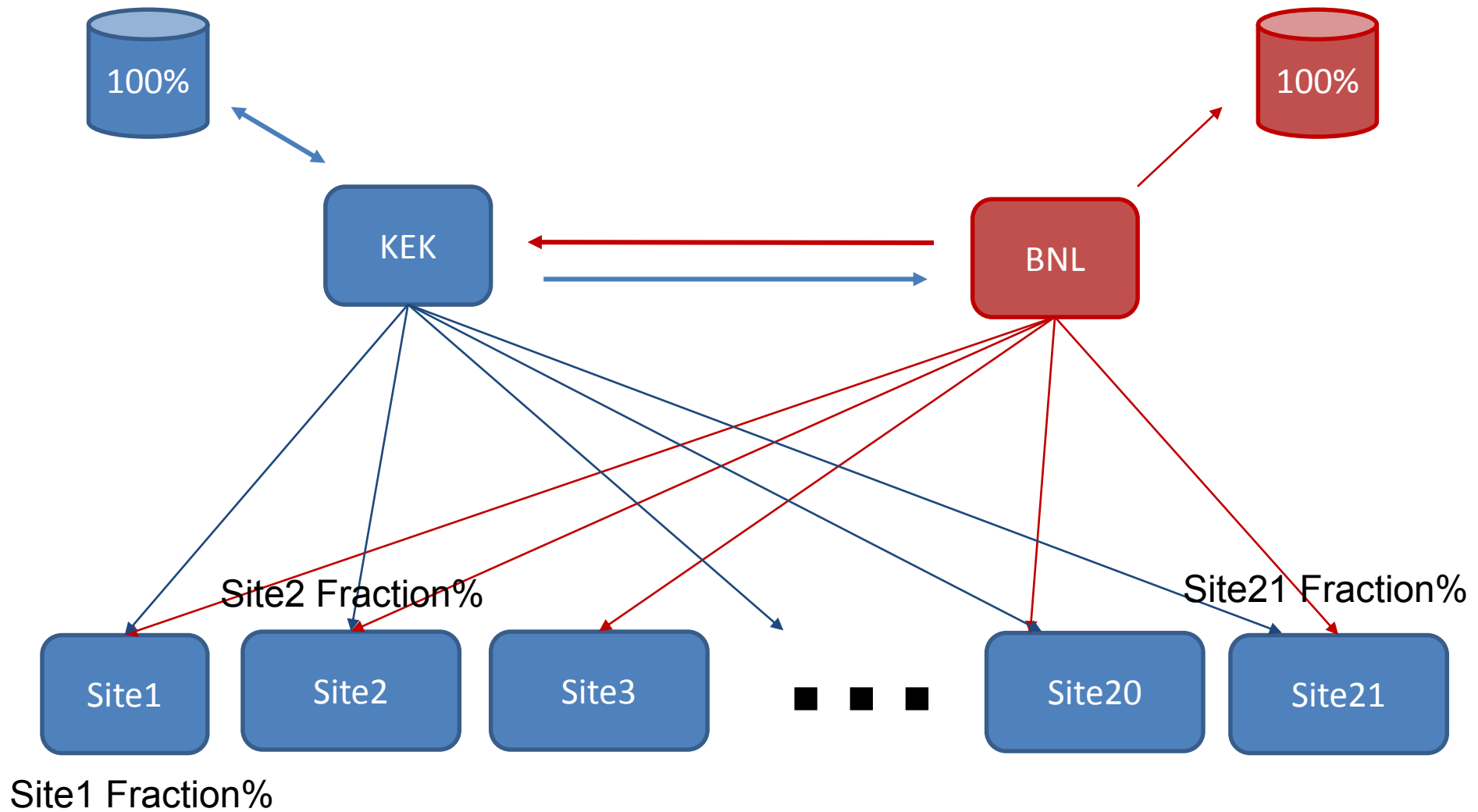
**Strategy under investigation: Each MC-Site will replicate the produced data, to 1 sites of different regions: the goal is to have 2 copies of the whole MC production.**

Site	Fraction %
Japan	21,7
Italy	13,8
USA	13,8
Germany	12,0
Russia	7,3
China	4,2
Korea	3,7
Canada	3,1
India	2,9
Australia	2,3
Slovenia	2,1
Taiwan	2,1
Mexico	1,8
Poland	1,8
France	1,6
Austria	1,0
Malaysia	1,0
Czech Rep.	0,8
VietNam	0,8
Thailand	0,5
Turkey	0,5
Ukraine	0,5
Saudi Arabia	0,3
Spain	0,3



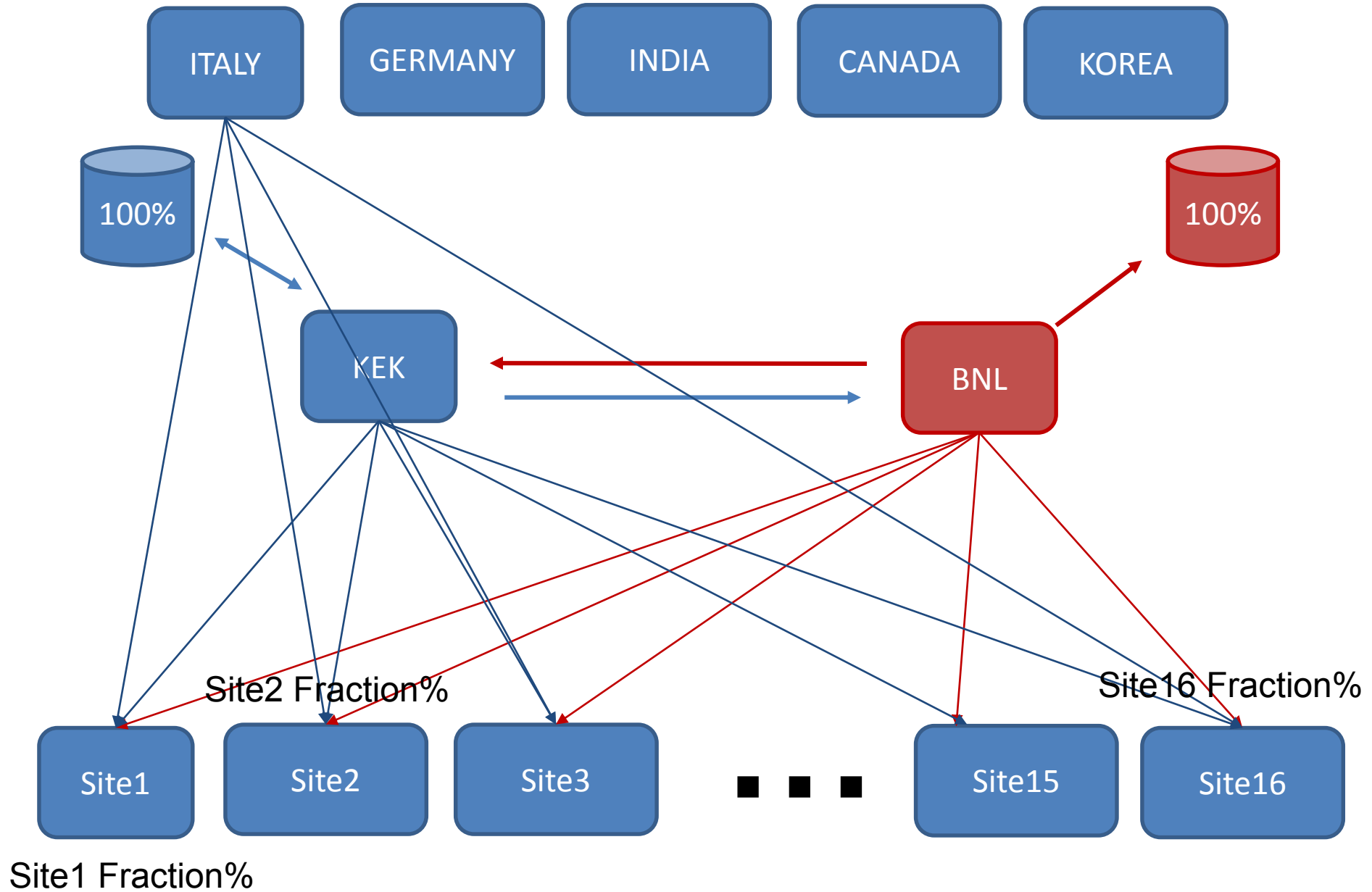


# MDST from Data Processing 2017-2020





# MDST from Data Processing 2021-2024





# Inbound traffic

	2018	2019	2020	2021	2022	2023	2024
<b>BNL</b>	0,32	1,99	3,38	1,67	2,15	2,39	2,28
<b>Italy</b>	0,30	0,16	0,21	1,20	1,55	1,77	1,73
<b>Germany</b>	0,26	0,14	0,18	1,17	1,50	1,70	1,65
<b>KEK</b>	0,46	0,24	0,33	0,40	0,53	0,82	0,98
<b>Korea</b>	0,08	0,04	0,06	0,54	0,69	0,76	0,72
<b>Canada</b>	0,07	0,04	0,05	0,53	0,68	0,74	0,69
<b>India</b>	0,06	0,03	0,04	0,53	0,67	0,73	0,68
<b>Russia</b>	0,16	0,08	0,11	0,13	0,18	0,28	0,33
<b>China</b>	0,09	0,05	0,06	0,08	0,10	0,16	0,19
<b>Australia</b>	0,05	0,03	0,04	0,04	0,06	0,09	0,11
<b>Slovenia</b>	0,04	0,02	0,03	0,04	0,05	0,08	0,09
<b>Taiwan</b>	0,04	0,02	0,03	0,04	0,05	0,08	0,09
<b>Mexico</b>	0,04	0,02	0,03	0,03	0,04	0,07	0,08
<b>Poland</b>	0,04	0,02	0,03	0,03	0,04	0,07	0,08
<b>France</b>	0,03	0,02	0,02	0,03	0,04	0,06	0,07
<b>Austria</b>	0,02	0,01	0,02	0,02	0,03	0,04	0,05
<b>Malaysia</b>	0,01	0,00	0,01	0,01	0,01	0,01	0,04
<b>Czech</b>	0,02	0,01	0,01	0,01	0,02	0,03	0,04
<b>Vietnam</b>	0,02	0,01	0,01	0,01	0,02	0,03	0,04
<b>Thailand</b>	0,01	0,01	0,01	0,01	0,01	0,02	0,02
<b>Turkey</b>	0,01	0,01	0,01	0,01	0,01	0,02	0,02
<b>Ukraine</b>	0,01	0,01	0,01	0,01	0,01	0,02	0,02
<b>Saudi Arabia</b>	0,01	0,00	0,00	0,00	0,01	0,01	0,01
<b>Spain</b>	0,01	0,00	0,00	0,00	0,01	0,01	0,01
	2.15	2.95	4.68	6.55	8.48	9.98	10,05





# Outbound traffic

	2018	2019	2020	2021	2022	2023	2024
KEK	0,49	2,10	3,56	5,23	6,72	7,10	6,54
BNL	0,30	0,30	0,41	0,28	0,36	0,62	0,72
Italy	0,30	0,12	0,15	0,24	0,32	0,53	0,64
Germany	0,26	0,10	0,13	0,22	0,29	0,48	0,58
Russia	0,16	0,06	0,08	0,09	0,13	0,19	0,25
Korea	0,08	0,03	0,04	0,08	0,10	0,18	0,21
Canada	0,07	0,03	0,03	0,07	0,09	0,17	0,19
India	0,06	0,03	0,03	0,07	0,09	0,16	0,18
China	0,09	0,04	0,05	0,05	0,07	0,11	0,14
Australia	0,05	0,02	0,03	0,03	0,04	0,06	0,08
Slovenia	0,04	0,02	0,02	0,03	0,04	0,05	0,07
Taiwan	0,04	0,02	0,02	0,03	0,04	0,05	0,07
Mexico	0,04	0,02	0,02	0,02	0,03	0,05	0,06
Poland	0,04	0,02	0,02	0,02	0,03	0,05	0,06
France	0,03	0,01	0,02	0,02	0,03	0,04	0,06
Austria	0,02	0,01	0,01	0,01	0,02	0,03	0,04
Malaysia	0,01	0,00	0,01	0,01	0,01	0,01	0,04
Czech	0,02	0,01	0,01	0,01	0,01	0,02	0,03
Vietnam	0,01	0,01	0,01	0,01	0,01	0,02	0,03
Thailand	0,01	0,00	0,01	0,01	0,01	0,01	0,02
Turkey	0,01	0,00	0,01	0,01	0,01	0,01	0,02
Ukraine	0,01	0,00	0,01	0,01	0,01	0,01	0,02
Saudi Aral	0,01	0,00	0,00	0,00	0,00	0,01	0,01
Spain	0,01	0,00	0,00	0,00	0,00	0,01	0,01
	2,15	2,96	4,68	6,55	8,49	9,99	10,06