Centre de Calcul de l'Institut National de Physique Nucléaire et de Physique des Particules

High Energy Physics : The Large Hadron Collider Data and Computing

8 September 2017

CCIN2P3

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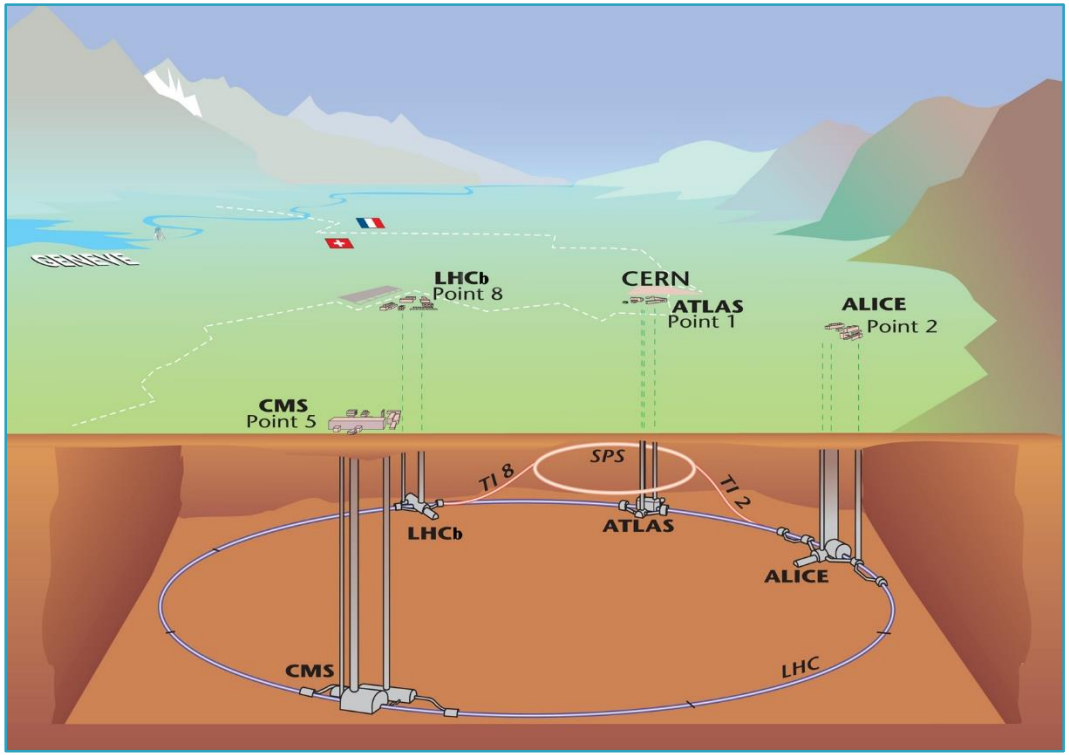
Content

- The Large Hadron Collider
- WLCG Project
  - Network
  - Data management and storage
  - Computing
- Evolution
- Conclusion

HEP: Large Hadron Collider and his experiments

- ~ 10,000 scientists and engineers
- ~ 100 countries
- Officially approved on 1994
  - First collisions on 2009
  - Scientifics data since 2010
- End of life > 2030

- The phenomena sought are very rare therefore it is necessary to have a lot of statistic and therefore a lot of data.



- Large Hadron Collider localized at CERN on the French-Swiss border.
- 4 main experiments.

Early some issues related to the computing were identified

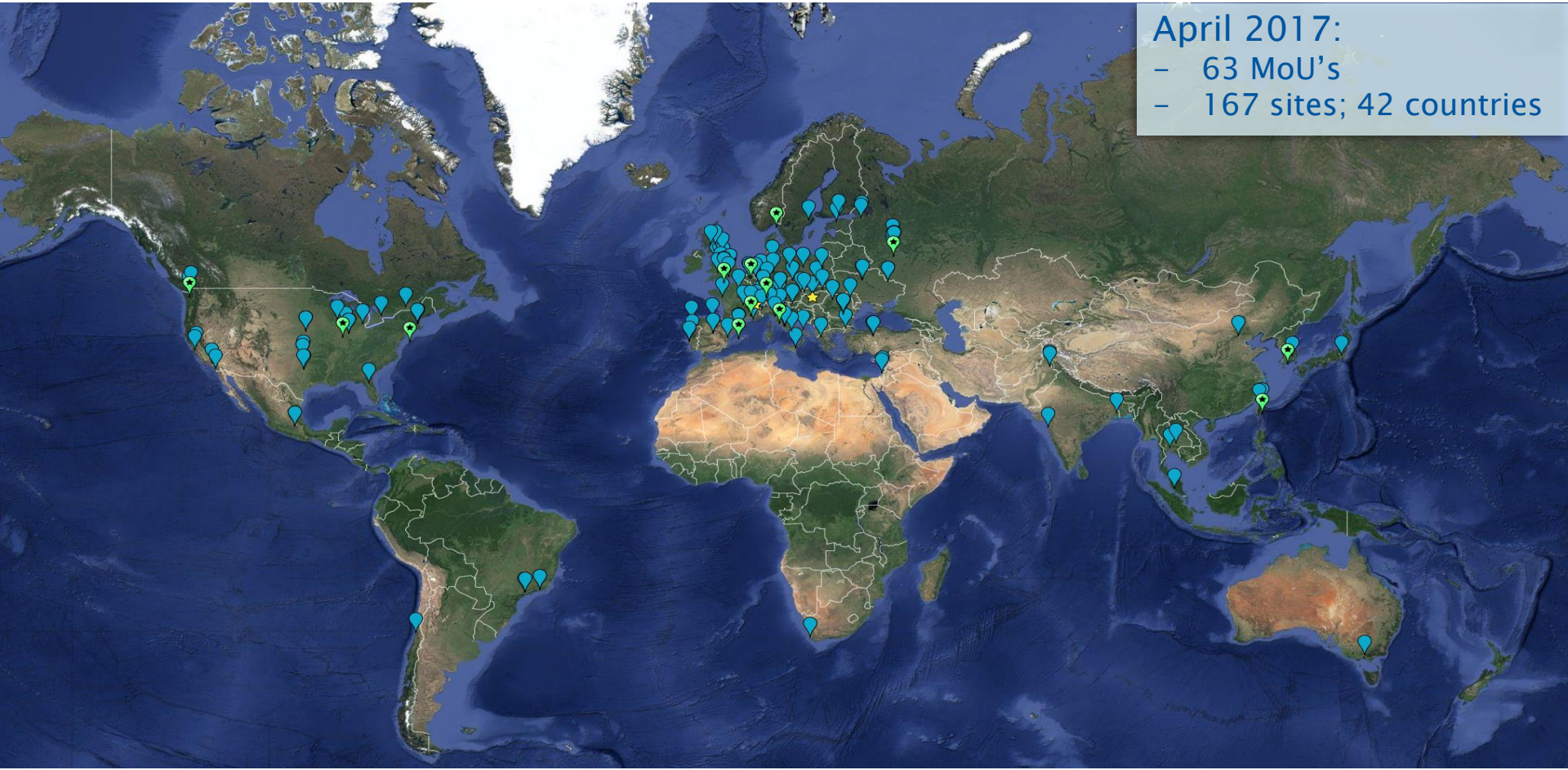
- How to manage the huge volume of data.
  - RAW data (initial data) from the experiments.
  - Derivate data used to perform analysis.
  - Simulated data
  - Each year it is ~25 Po of new data to manage.
- How to operate computing resources
  - Many thousand of CPU are requested to perform analysis, produced the simulation data, and process and reprocess the data.
- How to ensure that every scientist can have a efficient access to the data

Worldwide LHC Computing Grid

WLCG : Collaboration

- **W**orldWild **L**HC **C**omputing **G**rid is a project with the mission to provide global computing resources to store, distribute and analyses the data generated by the LHC.
- The WLCG infrastructure is linking up to national and international grid infrastructures.
  - WLCG resources are distributed all around the world.
  - Now some others infrastructures (cloud, HPC,….) are investigate/use by the project.
- ~ 170 computing centers in 42 countries participate to the project.
- The WLCG France project is the French part of the project and have to coordinate the resources provided by the French sites.

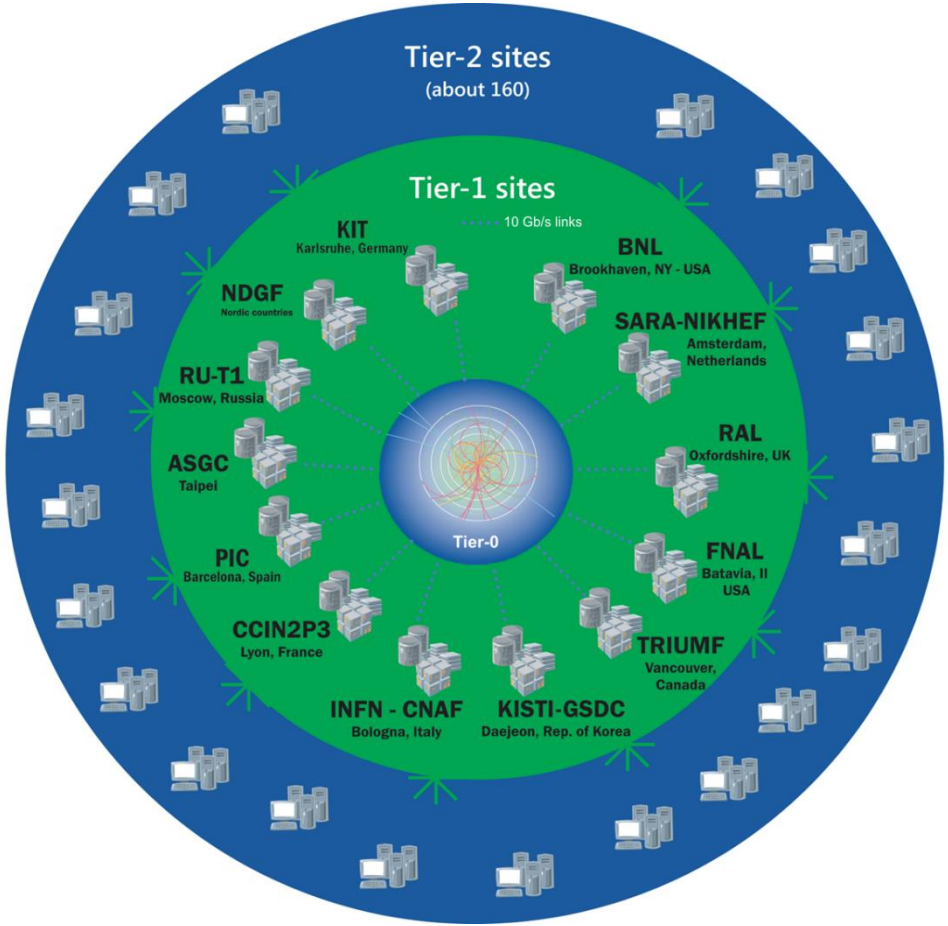
WLCG : Collaboration



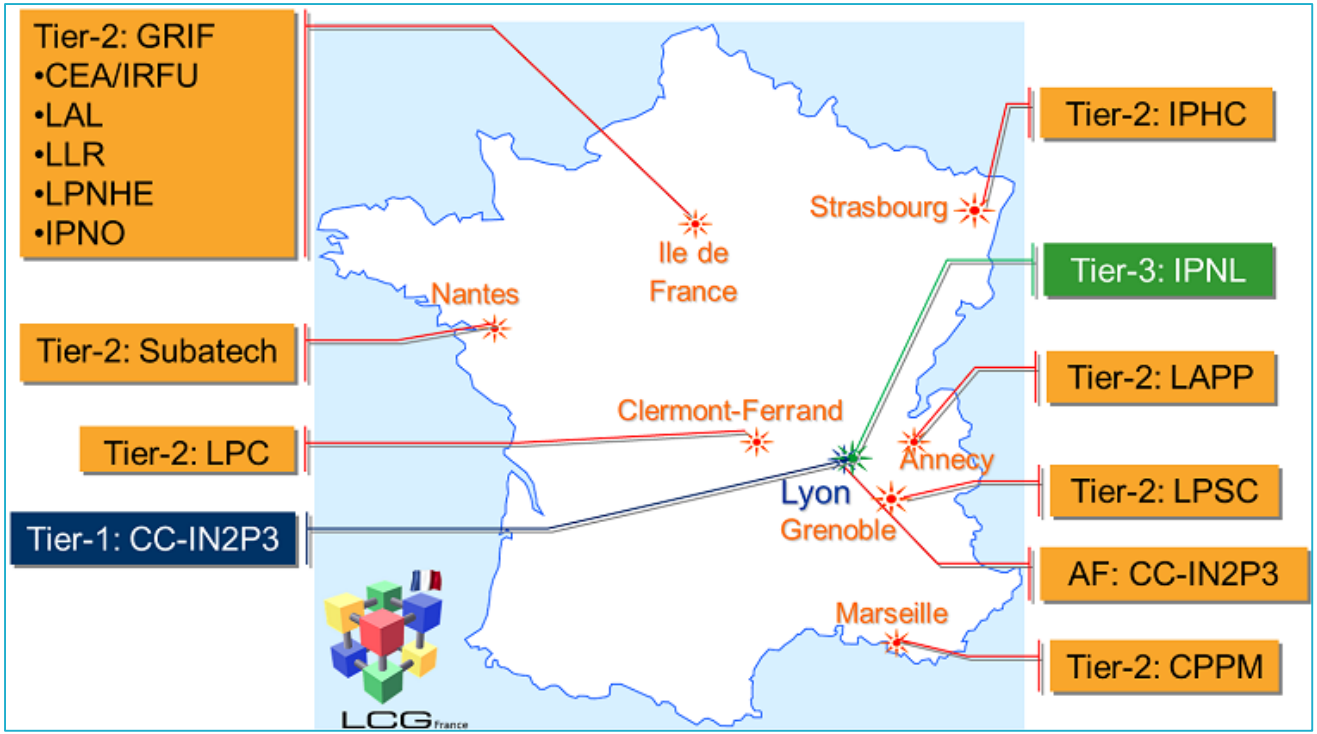
WLCG : Organisation of the resources / datacenter

- Tier 0 (CERN)
  - Production and recording of data
  - Reconstruction and distribution
- Tier 1 : 12 nationals sites
  - Permanent storage (tape provider)
  - Reprocessing and analysis
- Tier 2 : ~160 regionals sites
  - Simulation and end user analysis

Usage and functionalities affected to the Tier1 and Tier 2 are depending of the computing model of the experiments.



WLCG : French resources

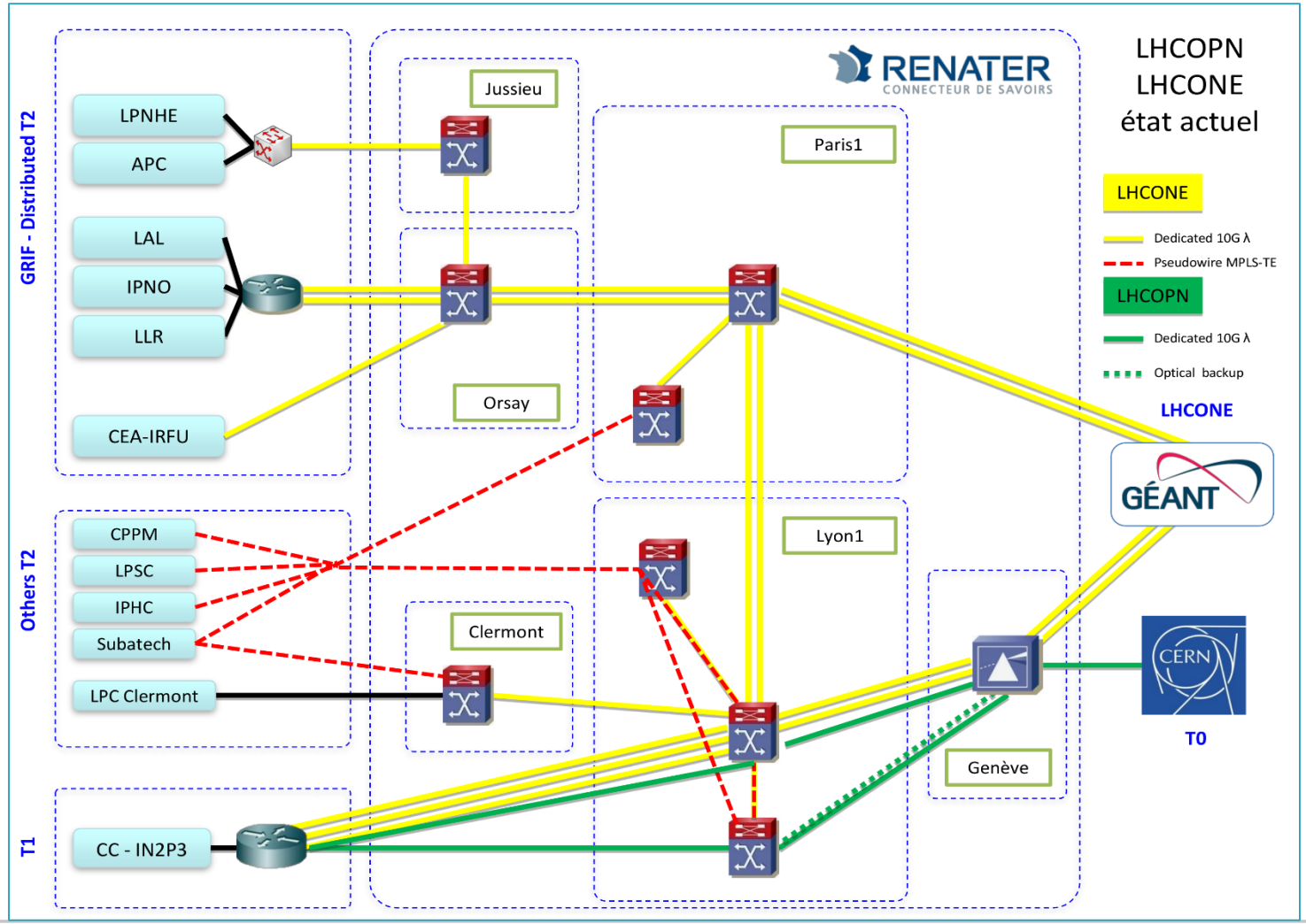


Role	Site	ALICE	ATLAS	CMS	LHCb
Tier-1	IN2P3-CC	✓	✓	✓	✓
Tier-2	IN2P3-CC-T2 (AF)		✓	✓	
	IN2P3-CPPM		✓		✓
	GRIF	✓	✓	✓	✓
	IN2P3-LPC	✓	✓		✓
	IN2P3-IPHC	✓		✓	
	IN2P3-LAPP		✓		✓
	IN2P3-LPSC	✓	✓		
	IN2P3-SUBATECH	✓			
Tier-3	IN2P3-IPNL	✓		✓	

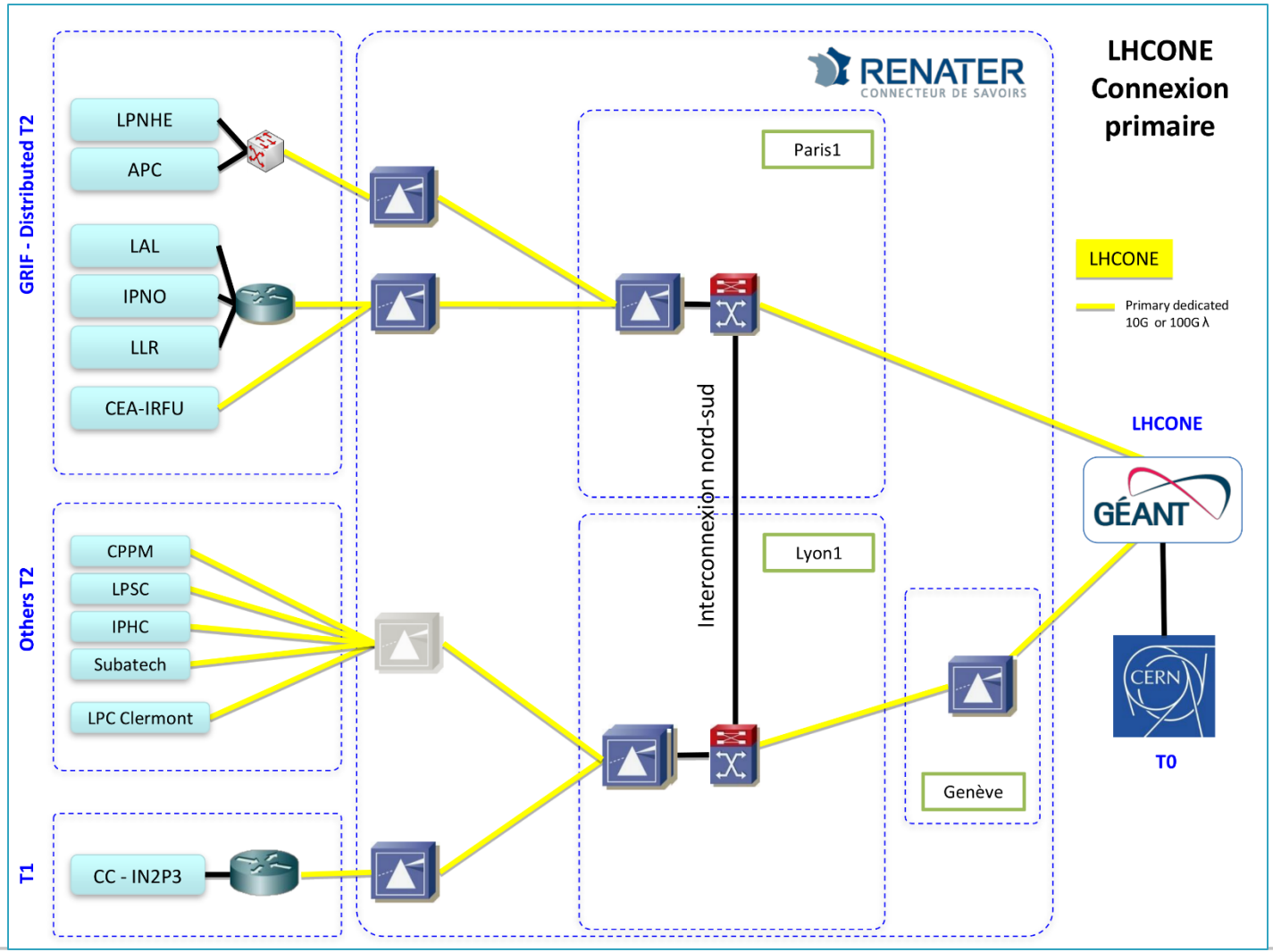
1 Tier 1 : ~10% of the WLCG global resource of Tiers 1
7 Tier 2 : ΣTier 2 resources = ~ Tier1

- Network reliability and capacities are the success keys of the LHC data analysis.
- Two dedicated network are provided for the LHC data by the network partners.
  - LHCOPN : A dedicated network between Tier 0 and Tier1. Raw data use this network. CERN – CC-IN2P3 is 20Gb/s link.
  - LHCONE: A dedicated network between Tier 2 and Tier1.
    - Not all the Tier 2 are connected to this network , it's depending of the national network provider. All the French Tier 2 are connected on it.
    - Tier 2 connection on this network is typically between 10Gb/s to 100Gb/s
      - CC-IN2P3 link is 30Gb/s
    - This network is use to exchange (and have a direct access to) the data for analysis. Data simulated are also exchanged via this network.

WLCG : FRENCH WLCG NETWORK



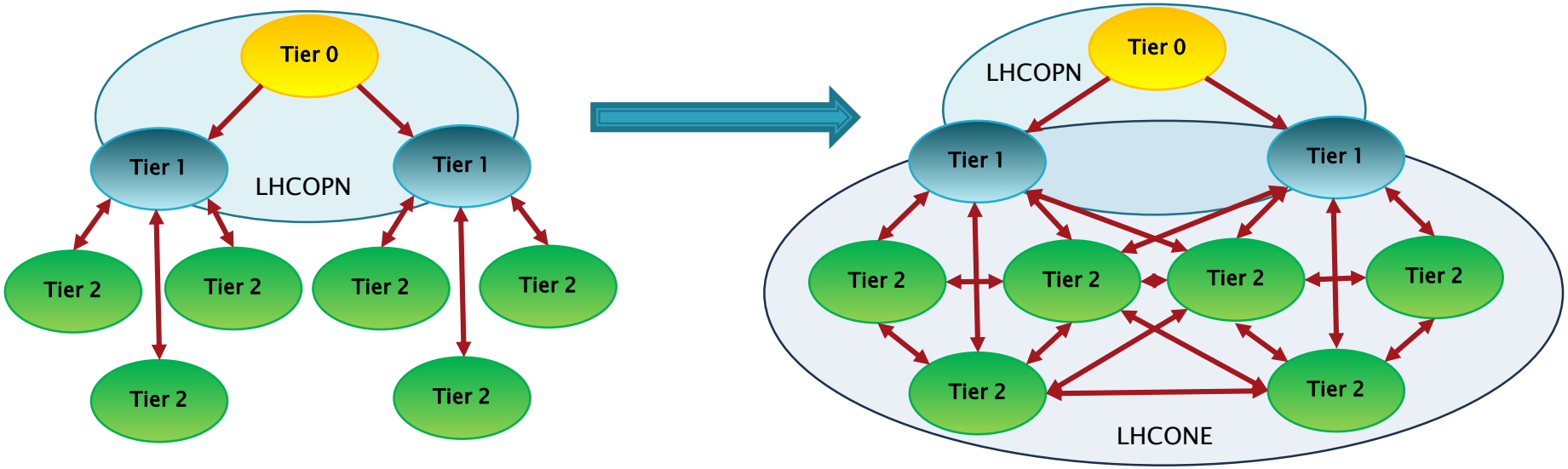
WLCG : FRENCH WLCG NETWORK NEXT STEP



WLCG : STORAGE AND DATA MANAGEMENT

- WLCG storage is based on two types of device.
  - Disk : 365 Po available on WLCG.
    - French : 34 Po
  - Tape : 370 Po available on WLCG.
    - French : 43 Po
- Each experiment has this own data management and computing model.
  - Some tools are share between them (service of data transfers, monitoring tools,…) some other are different for each experiment (catalogs,…).
- Concerning the data access two methods are considered
  - Move the data (or write in advance the data) on the appropriate site before computing.
  - Open a direct access on a remote site to read the data.
  - This two approaches are fully compatible and all the experiments use both approach depending of the task to perform.

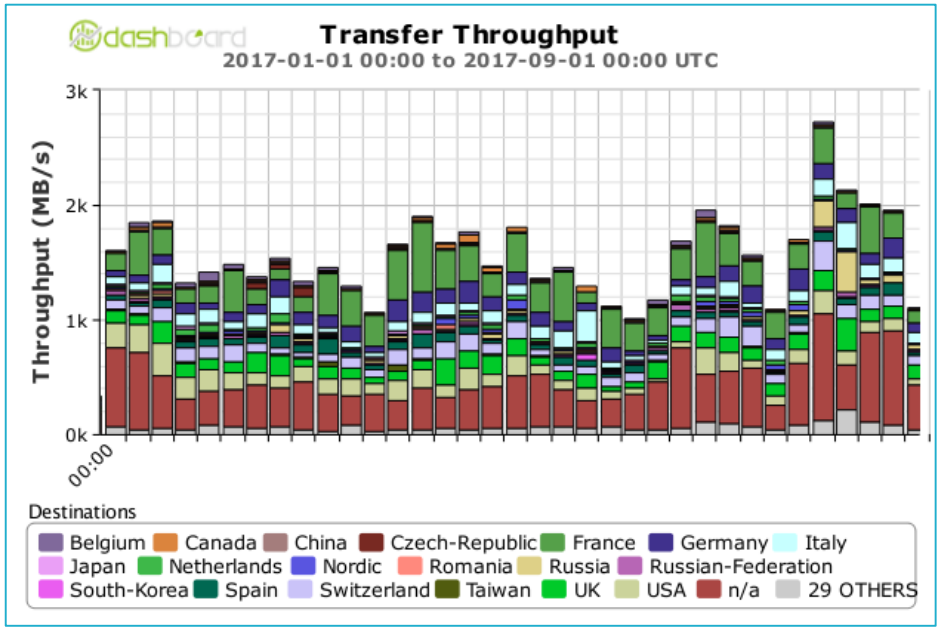
- The first model of data management of WLCG was based on hierarchical approach.



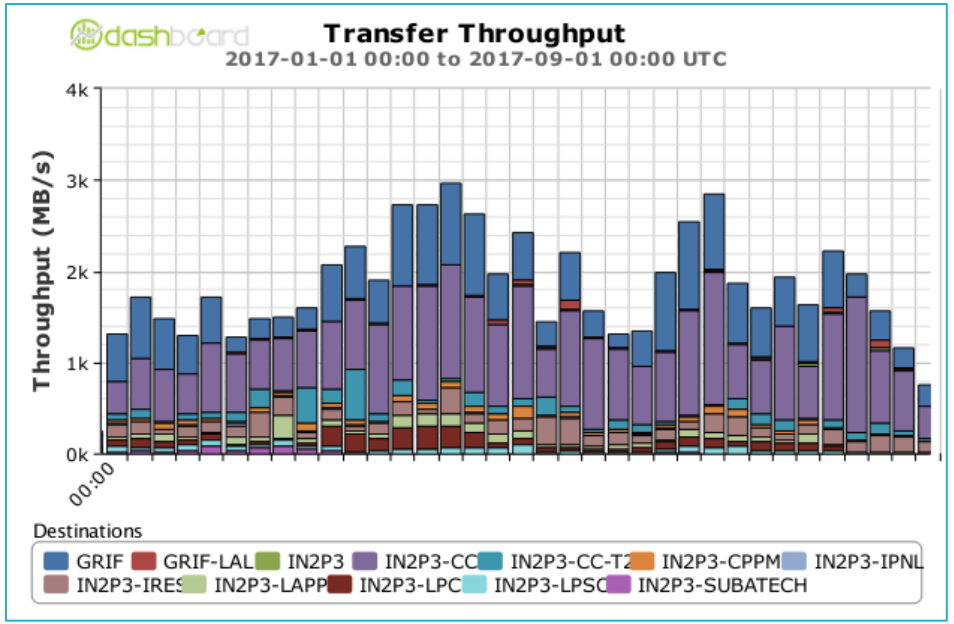
- Today the model of data management is based on flat hierarchy.

WLCG : DATA TRANSFERT

- Global data movement ~25 GBytes/s on WLCG



Data transfers throughput from 1 January 2017 to 1 September 2017 **from** French sites



Data transfers throughput from 1 January 2017 to 1 September 2017 **to** French sites

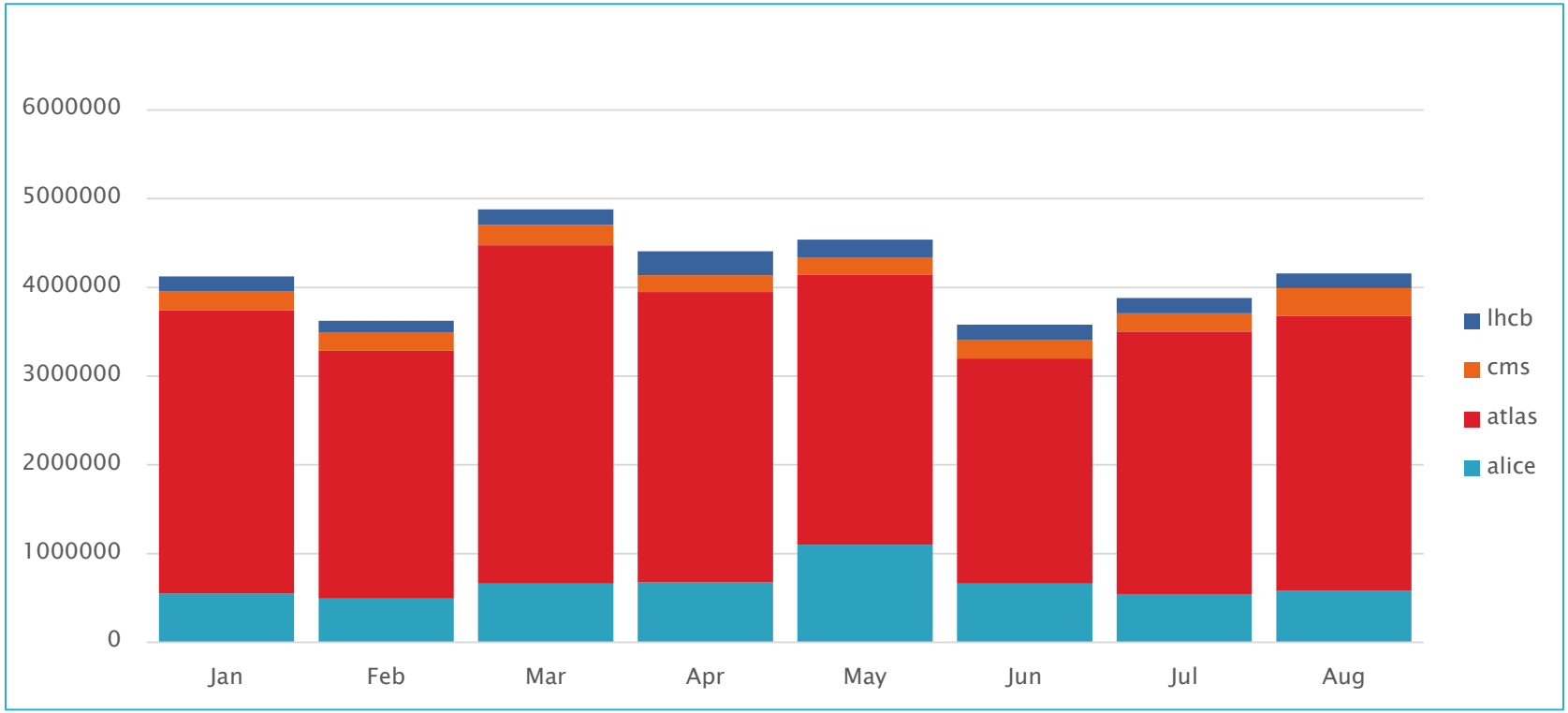
WLCG : COMPUTING

- ~700 000 core are available on WLCG infrastructure.
  - 600 000 core used continuously
  - French : ~48 000 core available.

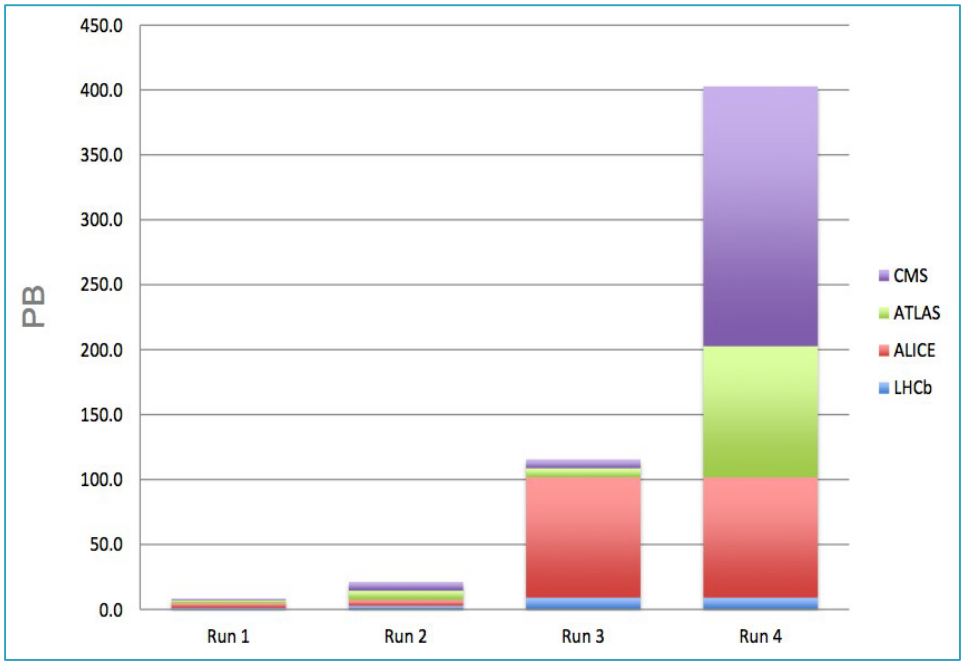
- Based usually on High Throughput Computing infrastructure.
  - Baseline of the computing in High Energy Physics is to process sequential tasks (analysis, simulation, reconstruction).
  - Some efforts was done to integrate other computing infrastructures (Cloud, High Performance Computing,…) on WLCG.

- Each experiment provide his own broker to distribute tasks on the WLCG infrastructure.

- Number of jobs executed on French WLCG sites



- Run 3 (2025) and 4 corresponding to a upgrade of the detectors and often to an upgrade of the data and computing model.



Data storage requirement for WLCG

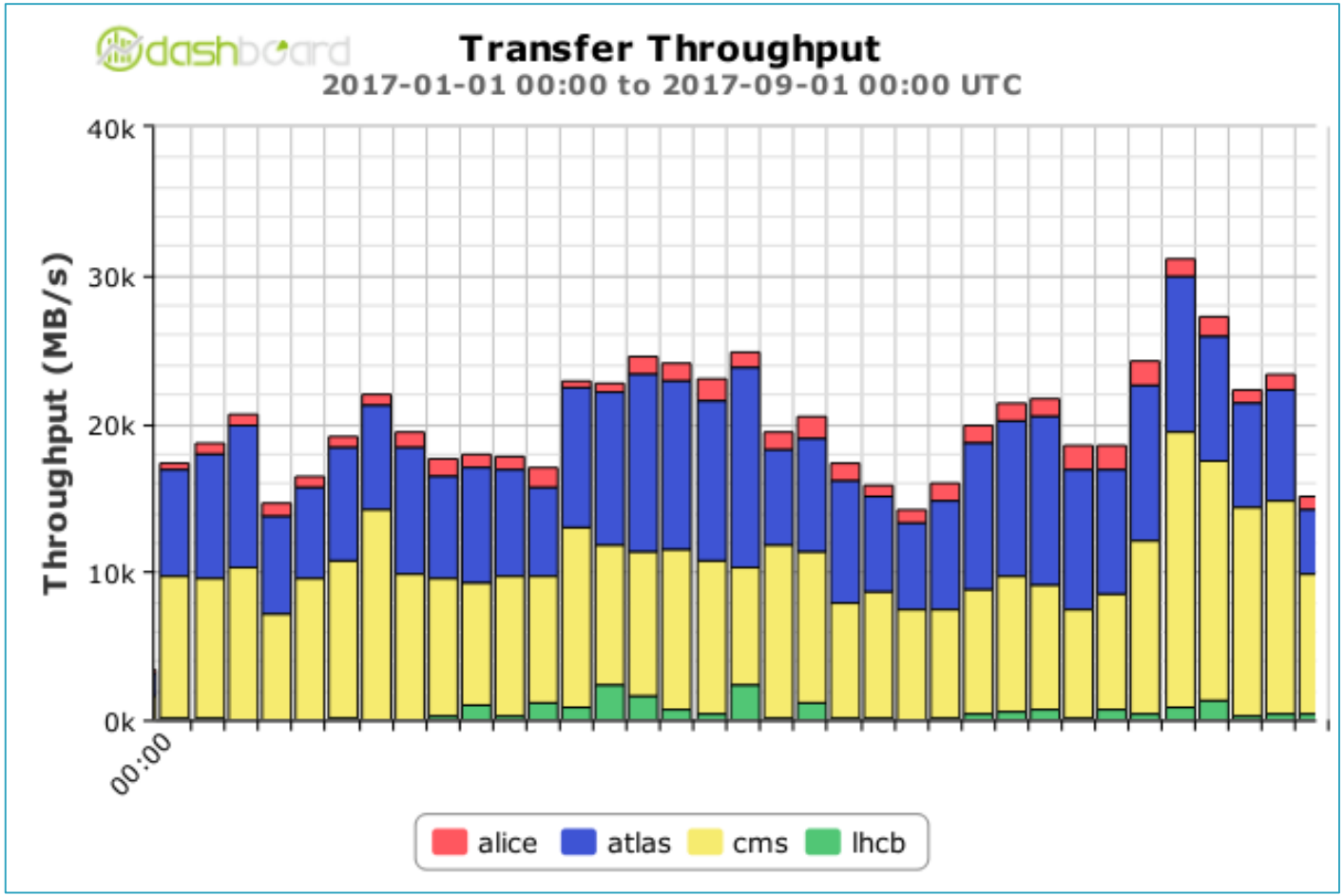
- Flat budget
- Hardware progress will not sufficient to provide the resources required to run 3 and run 4.
- Some effort on computing has to be done
  - HPC,FPGA, new devices
  - Refactoring of the software
  - New data format and data access
  - New analysis methods (machine learning, neuronal network,...

WLCG : CONCLUSIONS

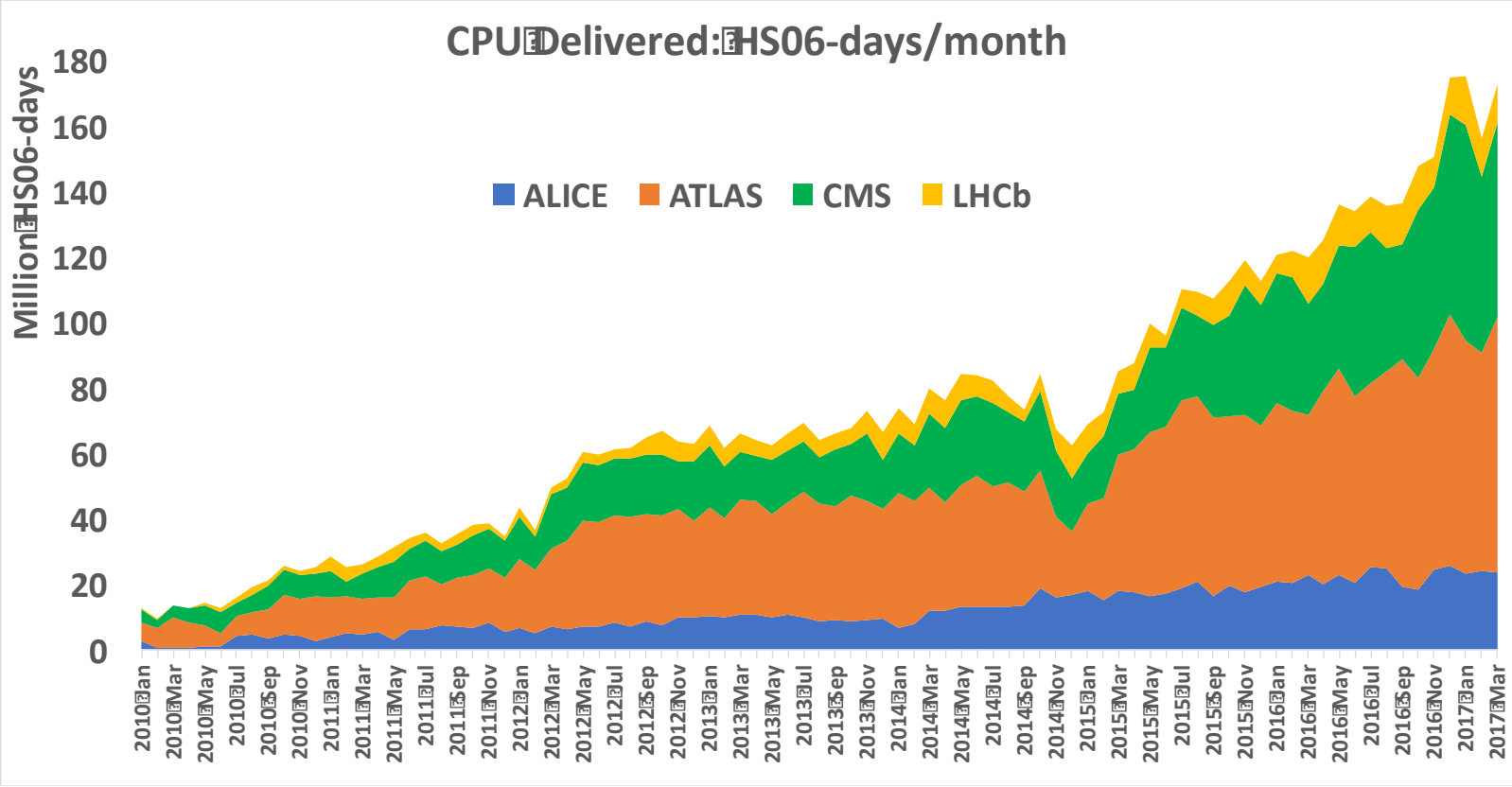
- WLCG is allowing since 2010 to manage and perform quickly the analysis of the LHC experiments with a high level of reliability.
  - Higgs boson discovery
  - ……
- WLCG operate a large distributed infrastructure.
- WLCG has a objective to continue to provide the computing and data management of the LHC.
  - Including new hardware/software/operational approach to satisfy the huge requirements of resources for the next 10 years

THANKS FOR YOUR ATTENTION

WLCG : DATA TRANSFERT



Data transfers throughput from 1 January 2017 to 1 September 2017 of the LHC experiments



New peak: ~180 M HS06-days/month

~ 600 k cores continuous