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

LHCb operations @ CC-IN2P3

By Aresh VEDAEE & Sybille VOISIN (04.12.24)

OUTLINE

- LHCb experiment
- CC-IN2P3 Data Center
- LHCb views on CC-IN2P3 Tier1
- CC-IN2P3 Tier1 views on LHCb
- Issues & challenges
- Conclusions

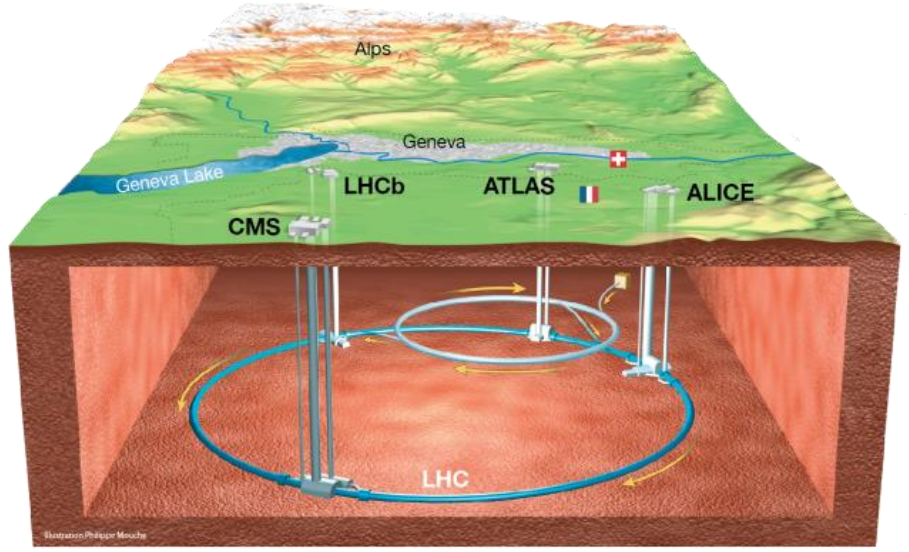
LHCb experiment

LHCb Scientific Objectives & Community

- **Scientific objectives:**

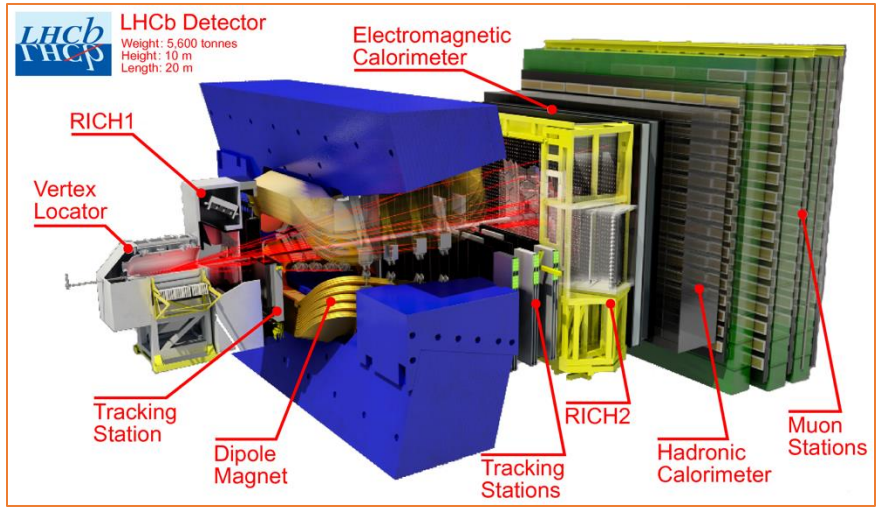
  - Open questions of the standard model of particle physics: the disappearance of antimatter in the course of the evolution of the universe, dark matter, or the hierarchy of masses and couplings of quarks.

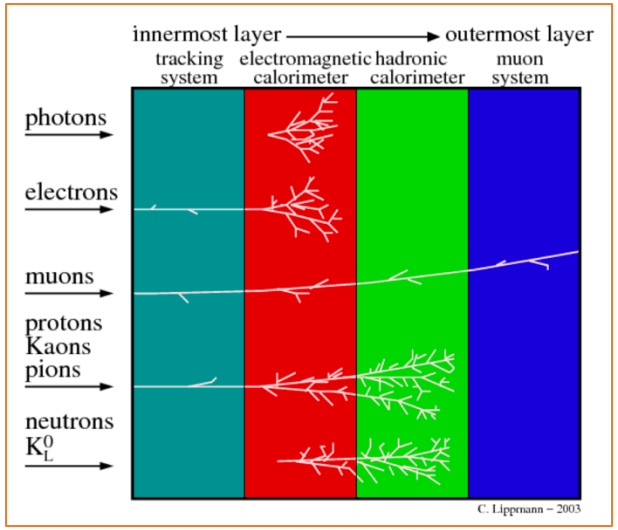
  - LHCb studies the CP violation and rare decays in the sector of beauty and charmed hadrons through spectroscopy. Since 2013, the LHCb collaboration has expanded its field of investigation by studying p-Pb and Pb-Pb forward collisions.



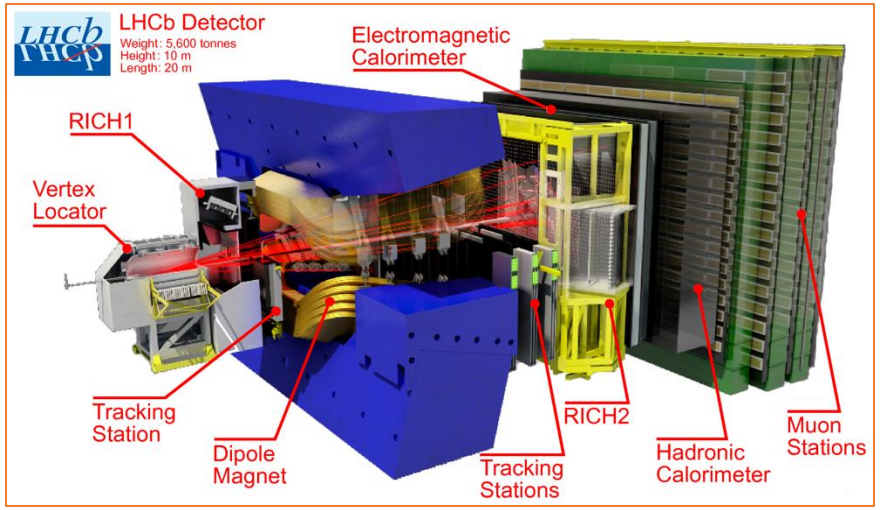
EXPERIMENTS	ATLAS EXPERIMENT	CMS	ALICE	LHCb
MEMBERS	6020	6002	2155	1608
INSTITUTES	264	257	174	95
COUNTRIES	47	59	41	22

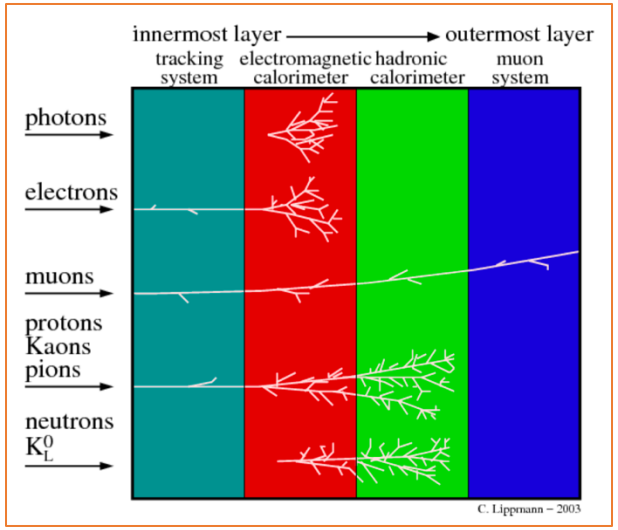
LHCb Detector & DAQ (1/3)

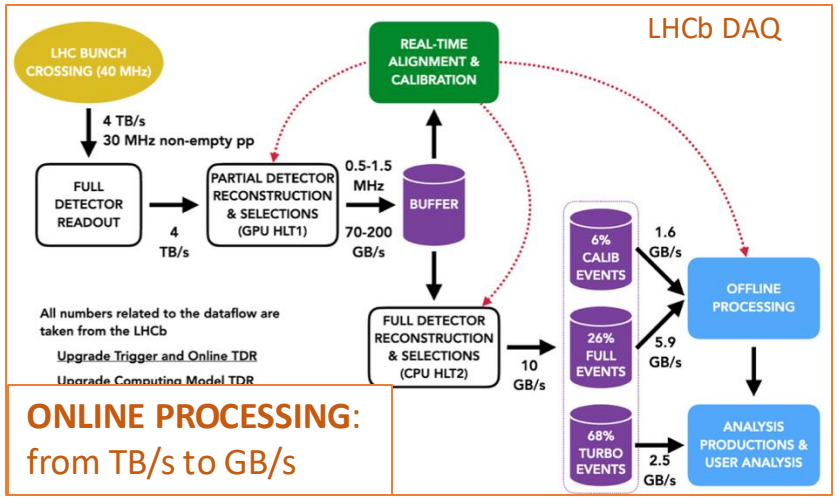




LHCb Detector & DAQ (2/3)

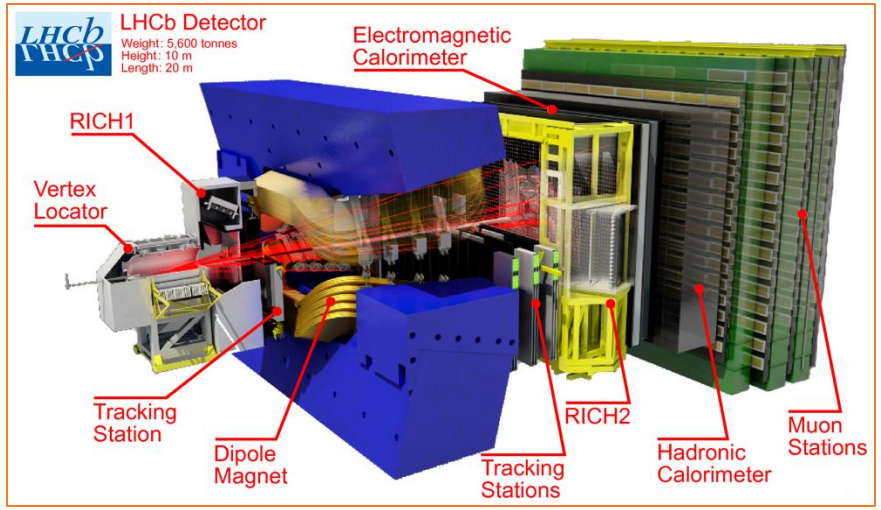


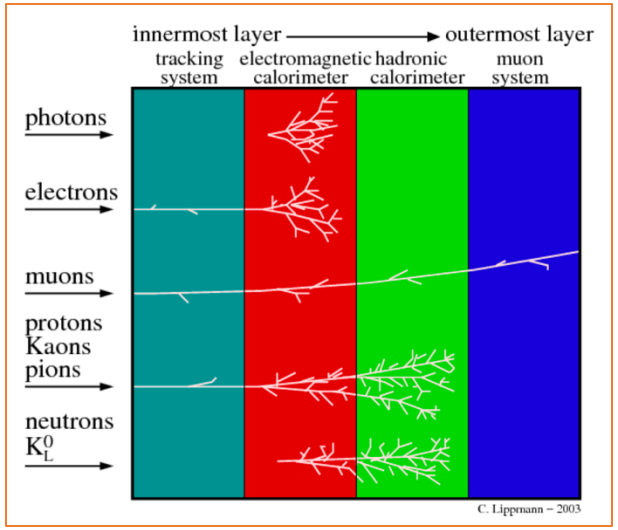


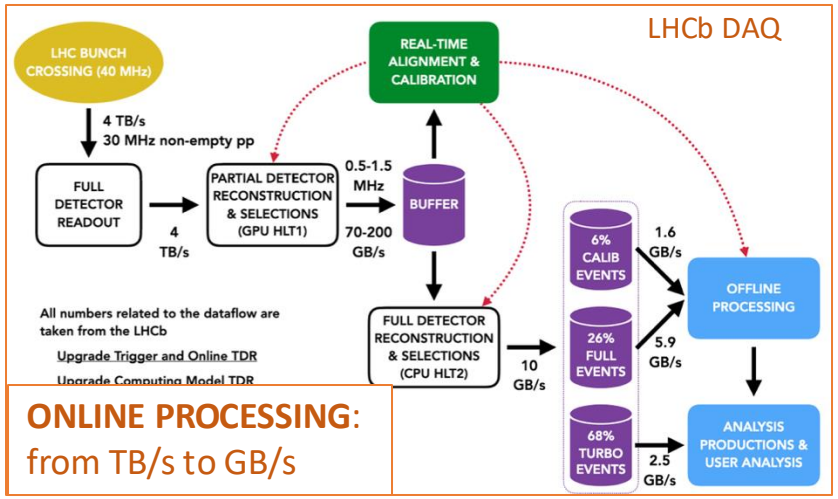


ONLINE PROCESSING: from TB/s to GB/s

LHCb Detector & DAQ (3/3)







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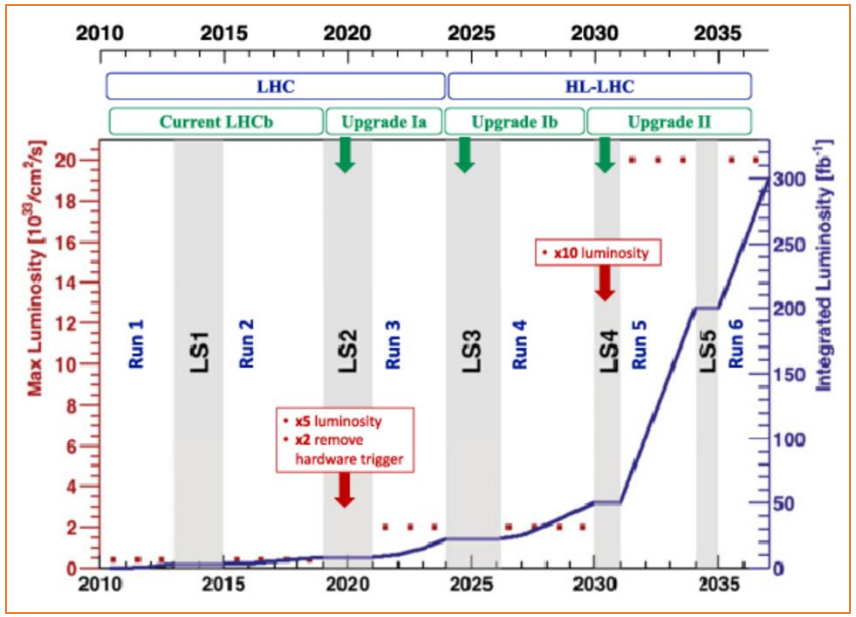
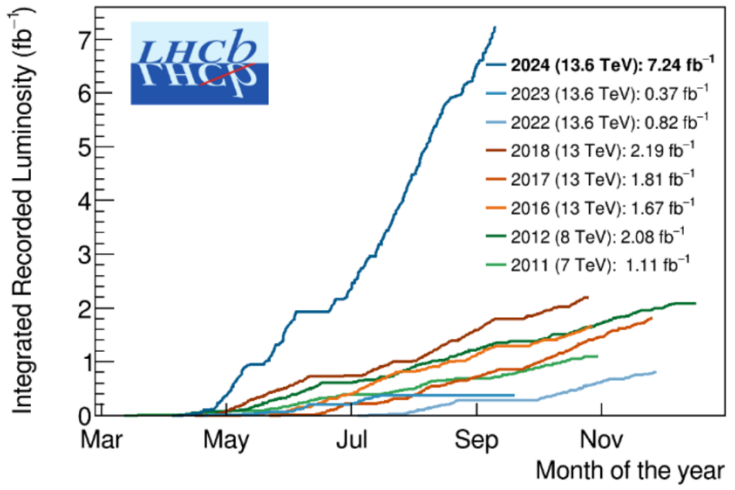
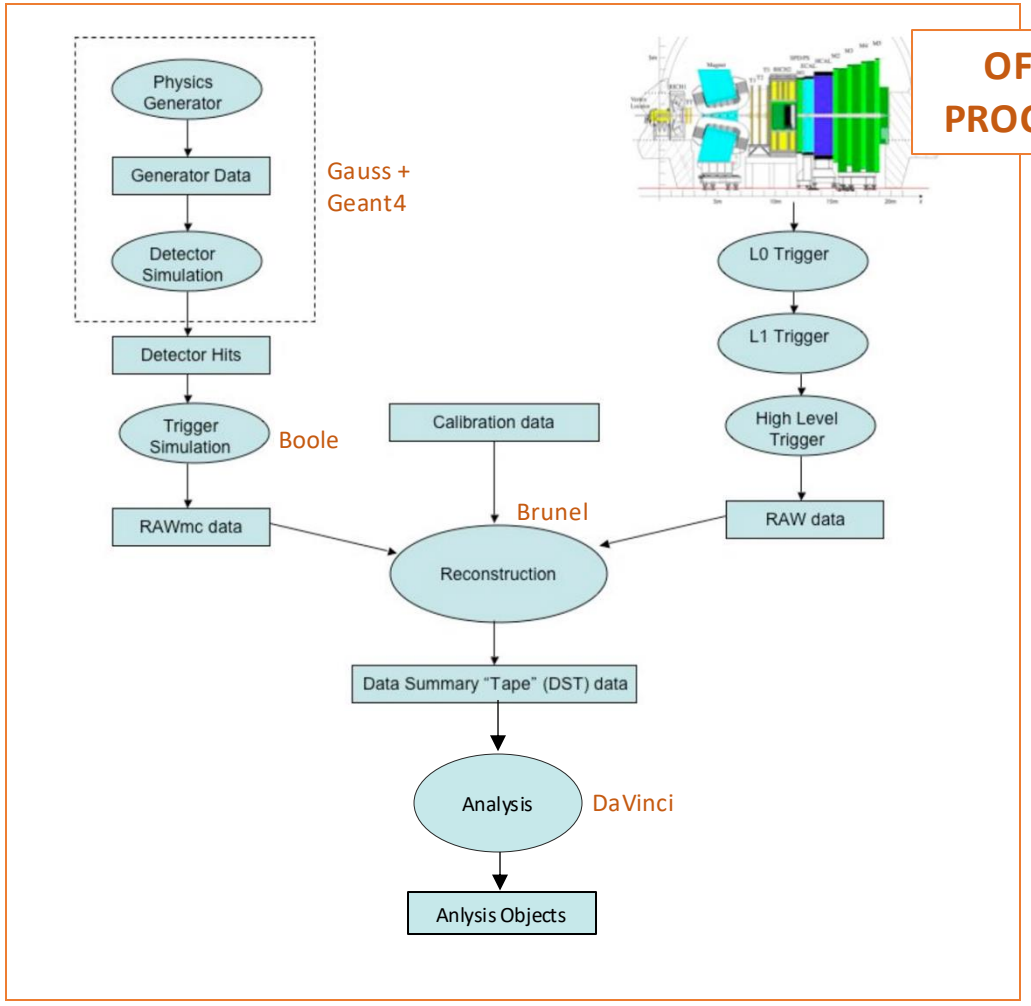


Recorded luminosity of 7.2 fb^{-1} in 2024 up to now: more than in the entire Run 2

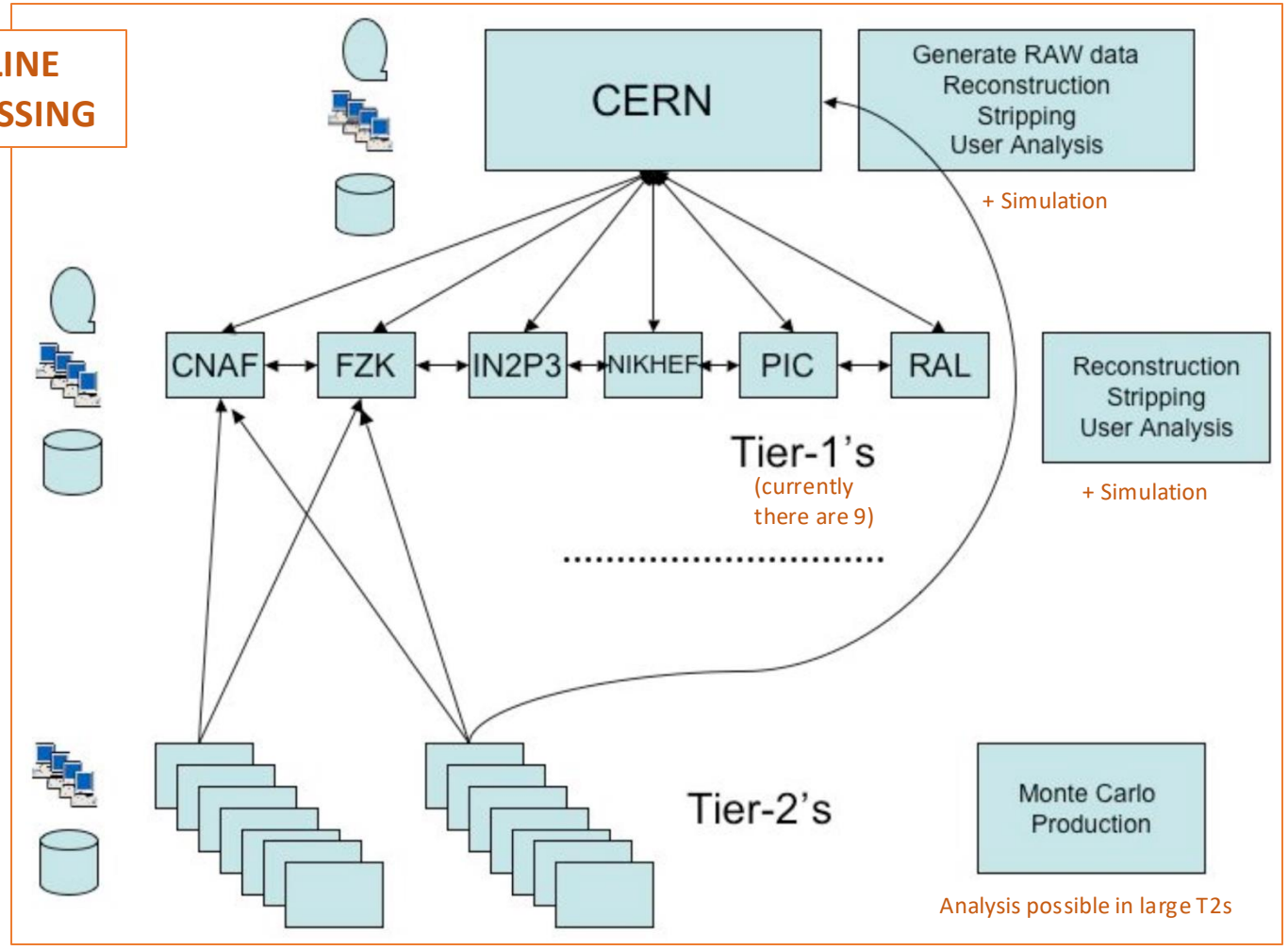


LHCb Detector/Triggers' upgrades & LHC upgrades (HL-LHC)

LHCb Workflows & Computing Model



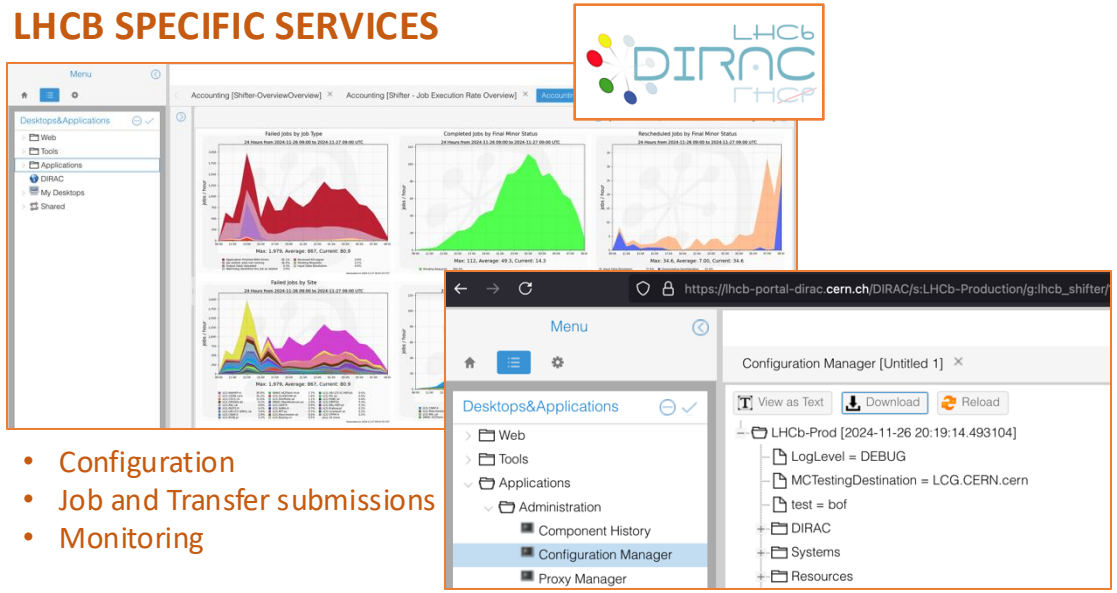
Workflows & Dataflows



Computing & Data distribution model

LHCb & WLCG services (1/3)

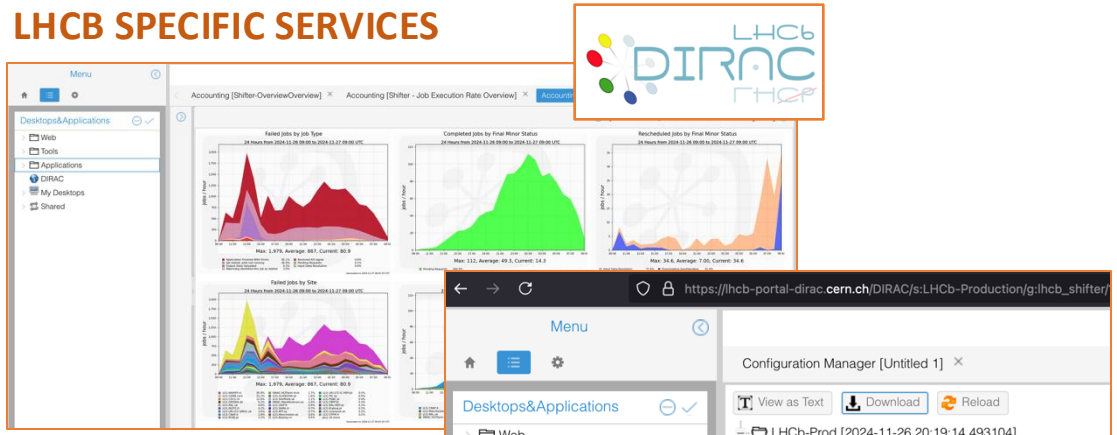
LHCB SPECIFIC SERVICES

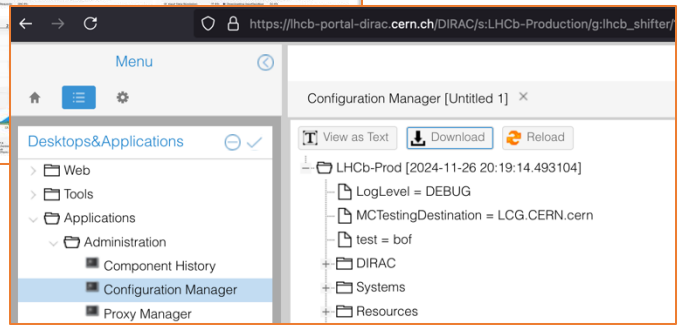


- Configuration
- Job and Transfer submissions
- Monitoring

LHCb & WLCG services (2/3)

LHCB SPECIFIC SERVICES



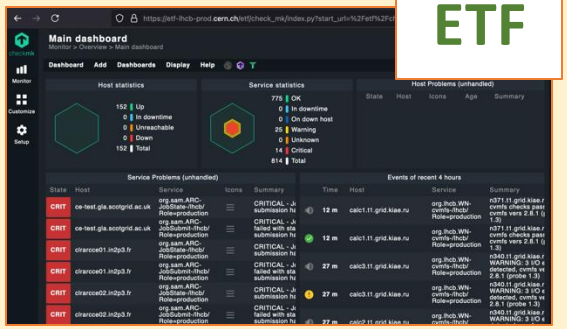


- Configuration
- Job and Transfer submissions
- Monitoring

VO SPECIFIC SERVICES

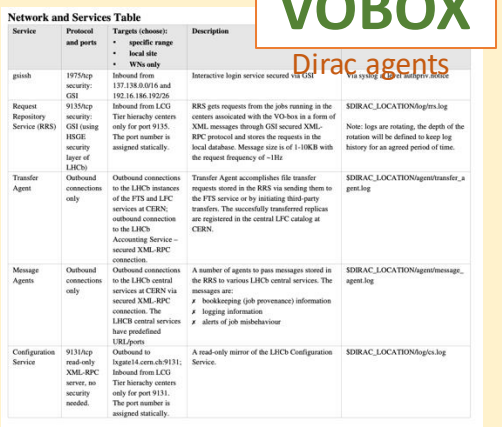
Functional tests

ETF

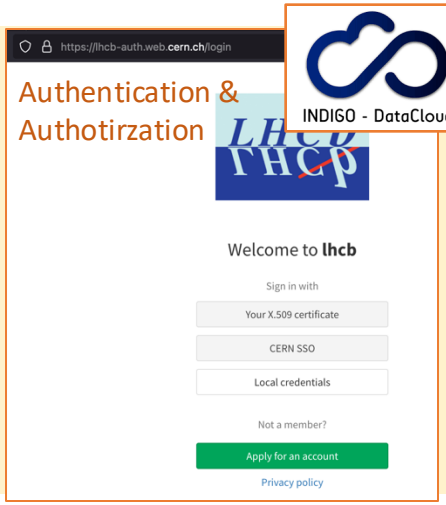


VOBOX

Dirac agents



Authentication & Authotirzation

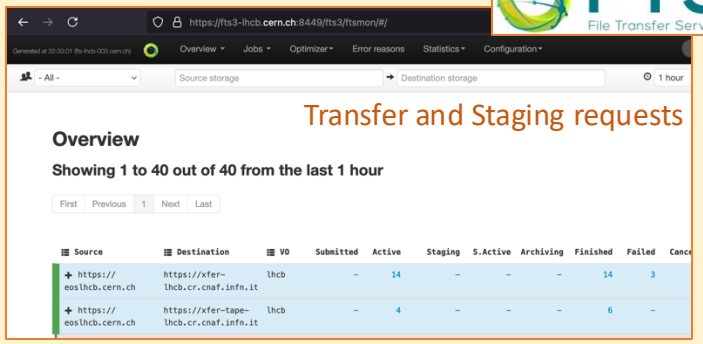


INDIGO - DataCloud

FTS

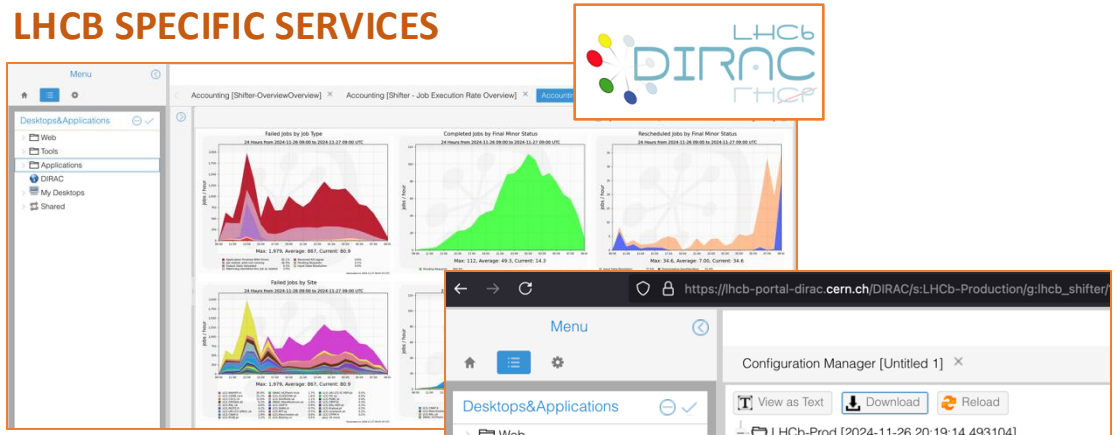
File Transfer Service

Transfer and Staging requests



LHCb & WLCG services (3/3)

LHCB SPECIFIC SERVICES



- Configuration
- Job and Transfer submissions
- Monitoring

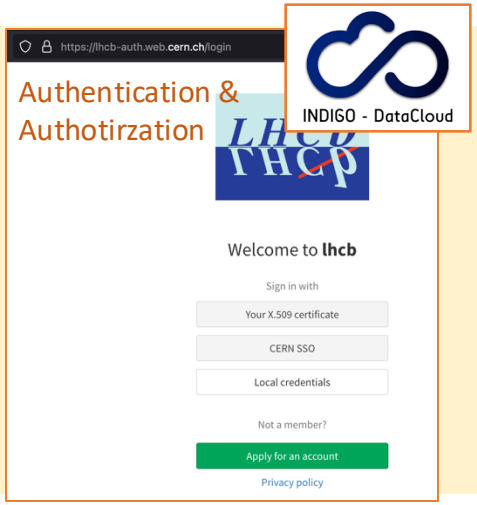
VOBOX

Dirac agents

Network and Services Table

Service	Protocol and ports	Targets (choose): • specific range • local site • WNs only	Description	
gsissh	1975/tcp security: GSI	Inbound from 137.138.0.0/16 and 192.16.186.192/26	Interactive login service secured via GSI	
Request Repository Service (RRS)	9135/tcp security: GSI (using HSGE security layer of LHCb)	Inbound from LCG Tier hierarchy centers only for port 9135. The port number is assigned statically.	RRS gets requests from the jobs running in the centers associated with the VO-box in a form of XML messages through GSI secured XML-RPC protocol and stores the requests in the local database. Message size is of 1-10KB with the request frequency of ~1Hz	$DIRAC_LOCATION/log/rrs.log Note: logs are rotating, the depth of the rotation will be defined to keep log history for an agreed period of time.
Transfer Agent	Outbound connections only	Outbound connections to the LHCb instances of the FTS and LFC services at CERN; outbound connection to the LHCb Accounting Service – secured XML-RPC connection.	Transfer Agent accomplishes file transfer requests stored in the RRS via sending them to the FTS service or by initiating third-party transfers. The successfully transferred replicas are registered in the central LFC catalog at CERN.	$DIRAC_LOCATION/agent/transfer_agent.log
Message Agents	Outbound connections only	Outbound connections to the LHCb central services at CERN via secured XML-RPC connection. The LHCB central services have predefined URL/ports	A number of agents to pass messages stored in the RRS to various LHCb central services. The messages are: ✗ bookkeeping (job provenance) information ✗ logging information ✗ alerts of job misbehaviour	$DIRAC_LOCATION/agent/message_agent.log
Configuration Service	9131/tcp read-only XML-RPC server, no security needed.	Outbound to lxgate14.cern.ch:9131; Inbound from LCG Tier hierarchy centers only for port 9131. The port number is assigned statically.	A read-only mirror of the LHCb Configuration Service.	$DIRAC_LOCATION/log/cs.log

Authentication & Authotirzation



VO SPECIFIC SERVICES

Functional tests

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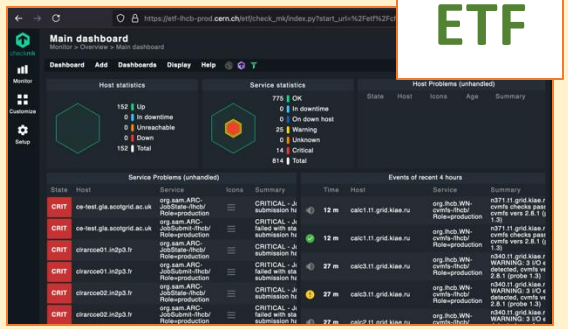
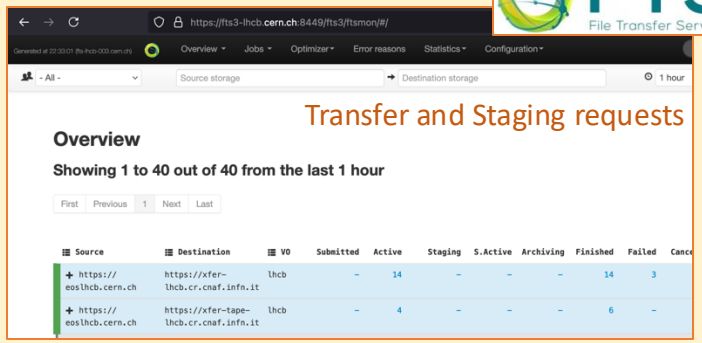
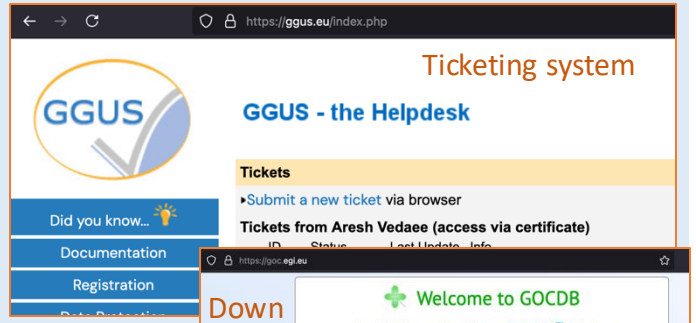


Transfer and Staging requests

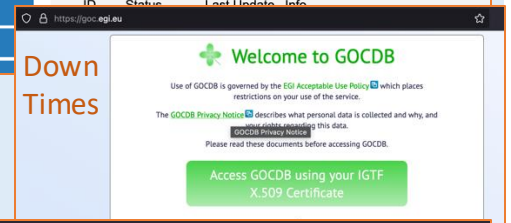


VO SHARED SERVICES

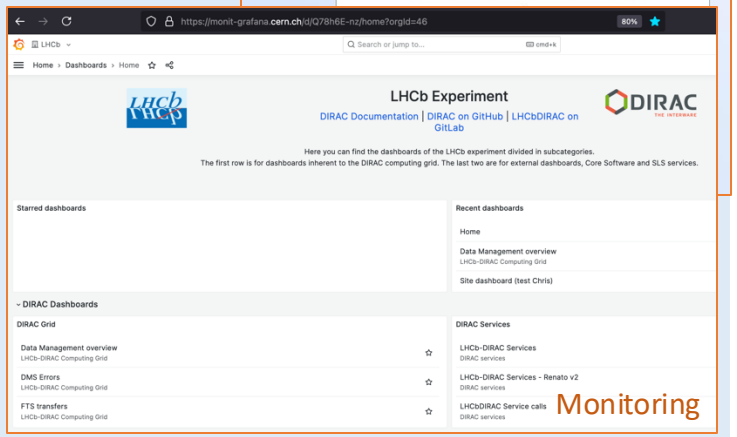
Ticketing system



Down Times

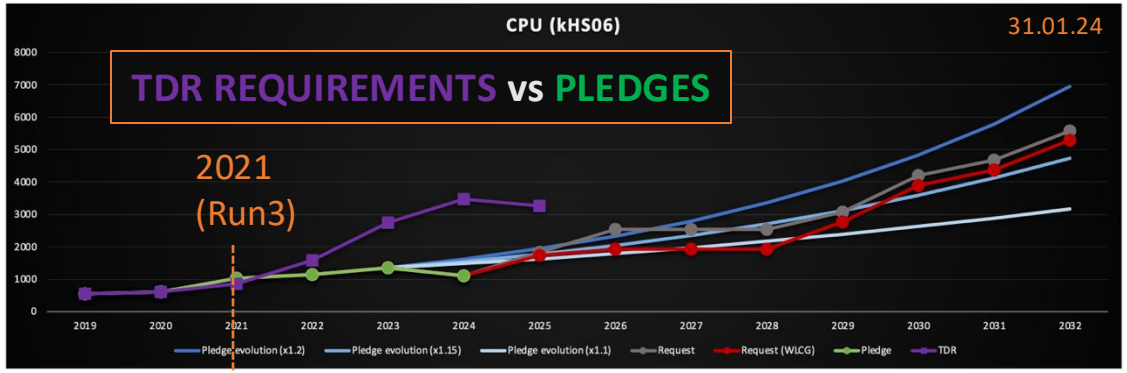


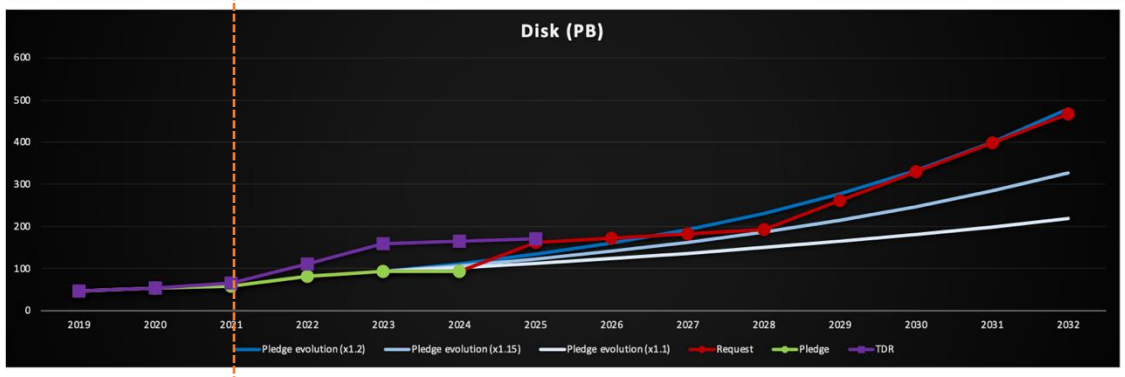
Monitoring

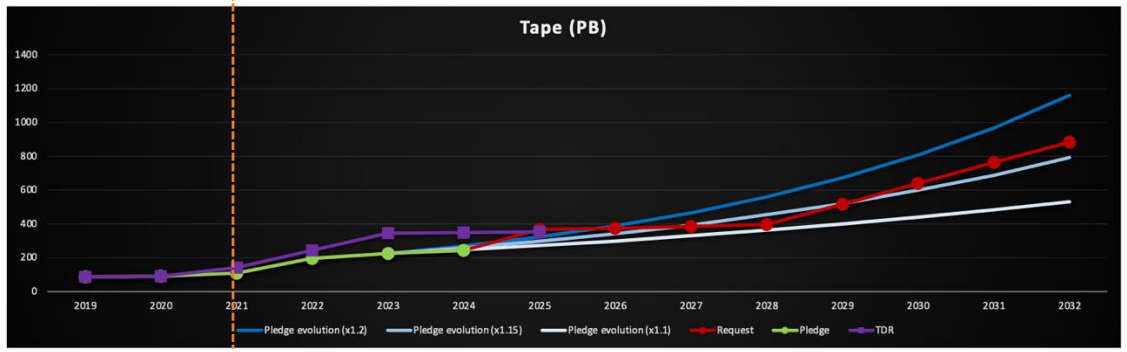


LHCb Requirements, Pledges, Consumption (1/3)

LHCb Requirements, Pledges, Consumption (2/3)







PLEDGES ’24 (30.11.24)

Tier	Pledge Type	Year	LHCb Required	LHCb Pledged	LHCb Balance
0	CPU	2024	174000	174000	0 %
0	Disk	2024	30600	30600	0 %
0	Tape	2024	117100	117100	0 %
1	Tape	2024	133300	133155	0 %
1	Disk	2024	61200	57686	-6 %
1	CPU	2024	572000	692293	21 %
2	Disk	2024	11800	7881	-33 %
2	CPU	2024	319000	355559	11 %

All Tier1 (including new Tier1s: NCBJ & IHEP)

LHCb Requirements, Pledges, Consumption (3/3)

PLEDGES '24 (30.11.24)

Tier	Pledge Type	Year	LHCb Required	LHCb Pledged	LHCb Balance
0	CPU	2024	174000	174000	0 %
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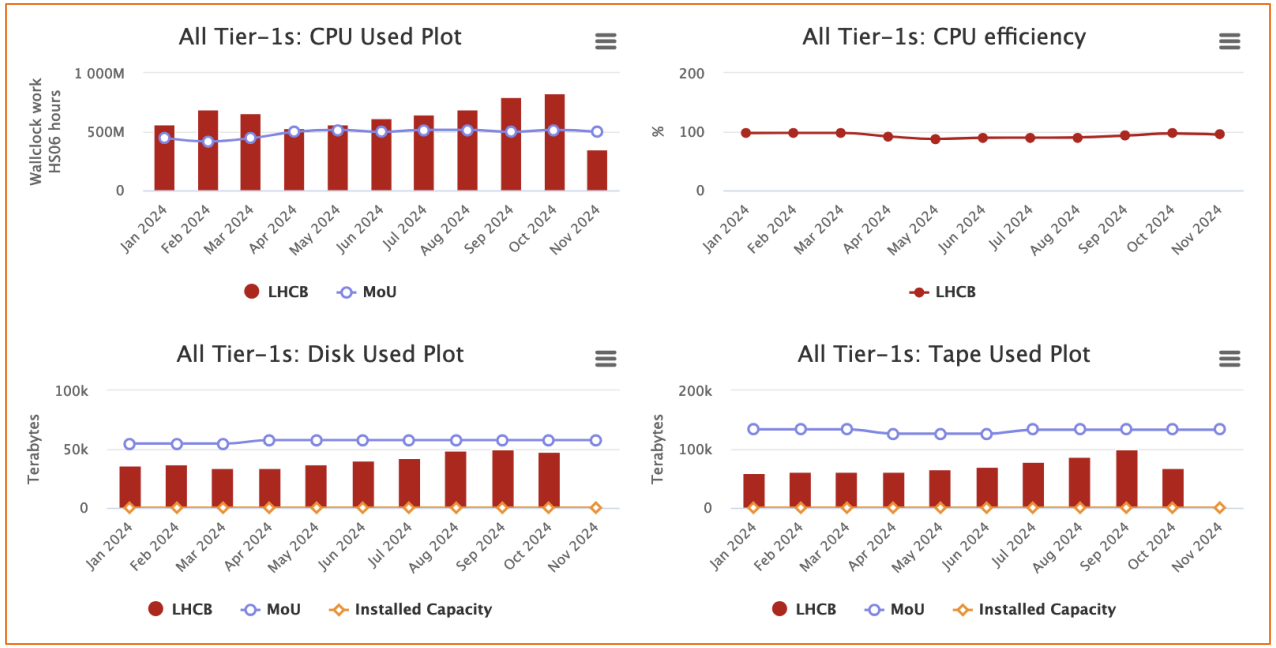
All Tier1 (including new Tier1s: NCBJ & IHEP)

CONSUMPTION '24

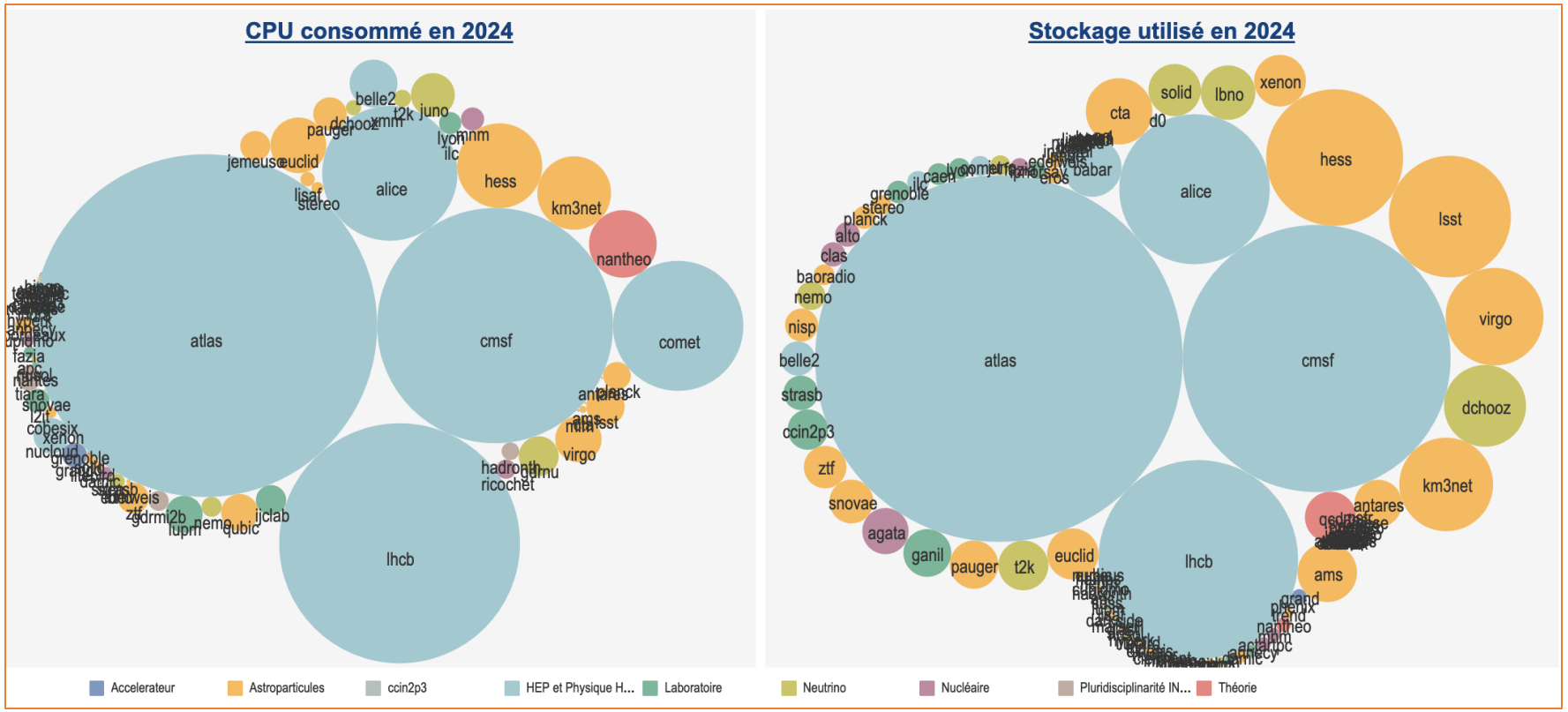


CC-IN2P3 Data Center

CC-IN2P3 (1/2)

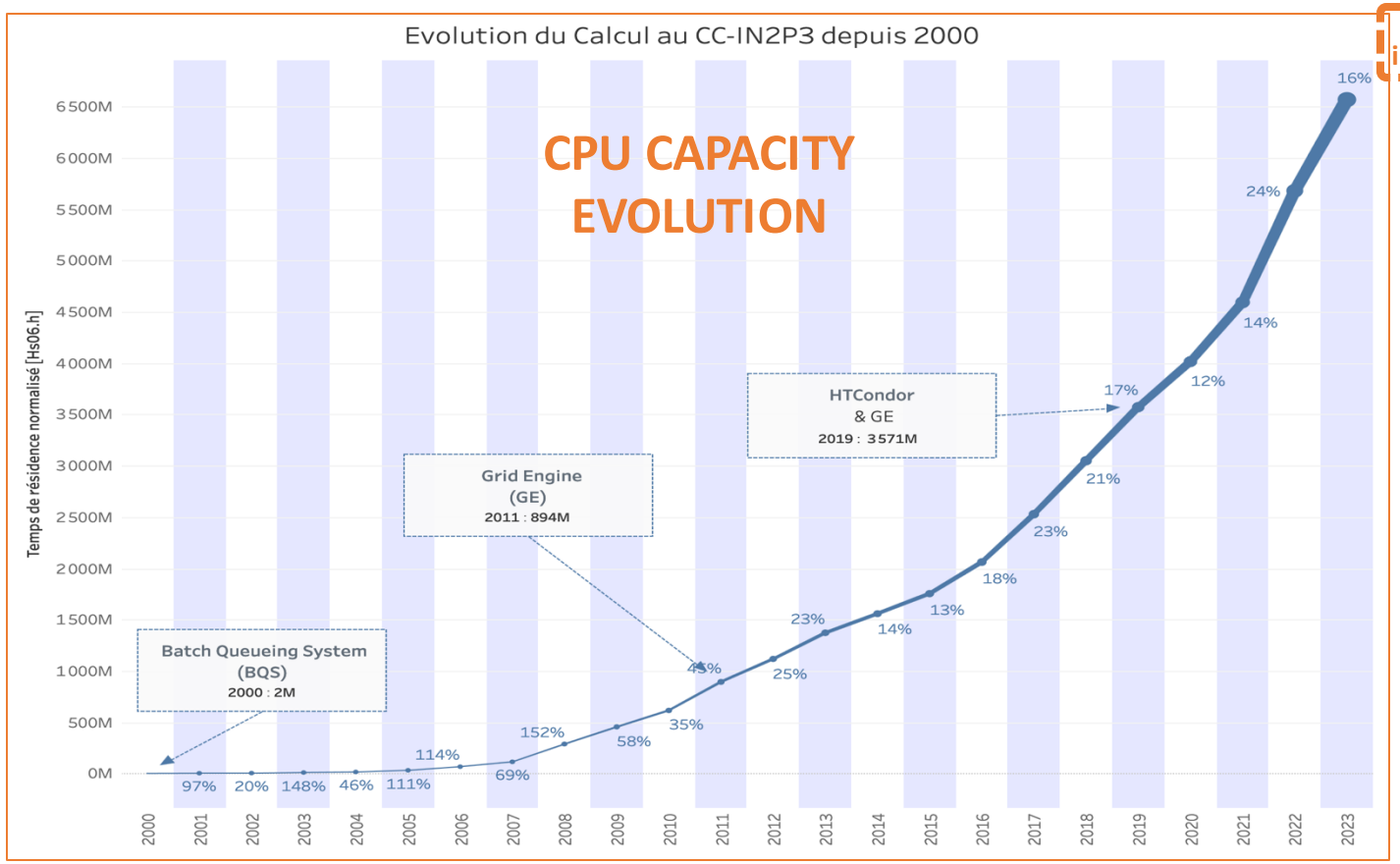
Computing	
CPU power	940 kHS23
CPUs	1426
CPU slots	57K
Worker Nodes	713
Jobs	58M/year
Users	900
Groups	104

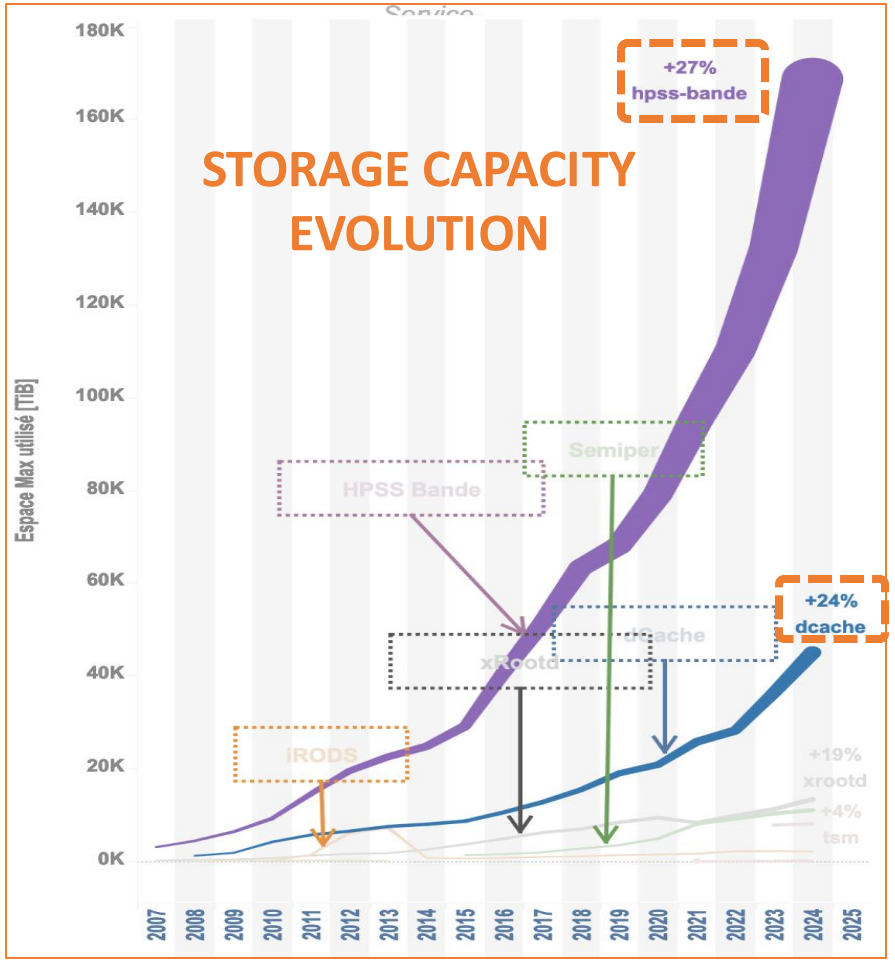
Storage	
Disk	92PB
Tape	217PB
Occupancy	282PB max
Files	8.7B
Users	4568
Groups	221



>60% of CC-IN2P3 computing/storage resources
are consumed by the LHC Experiments

CC-IN2P3 (2/2)



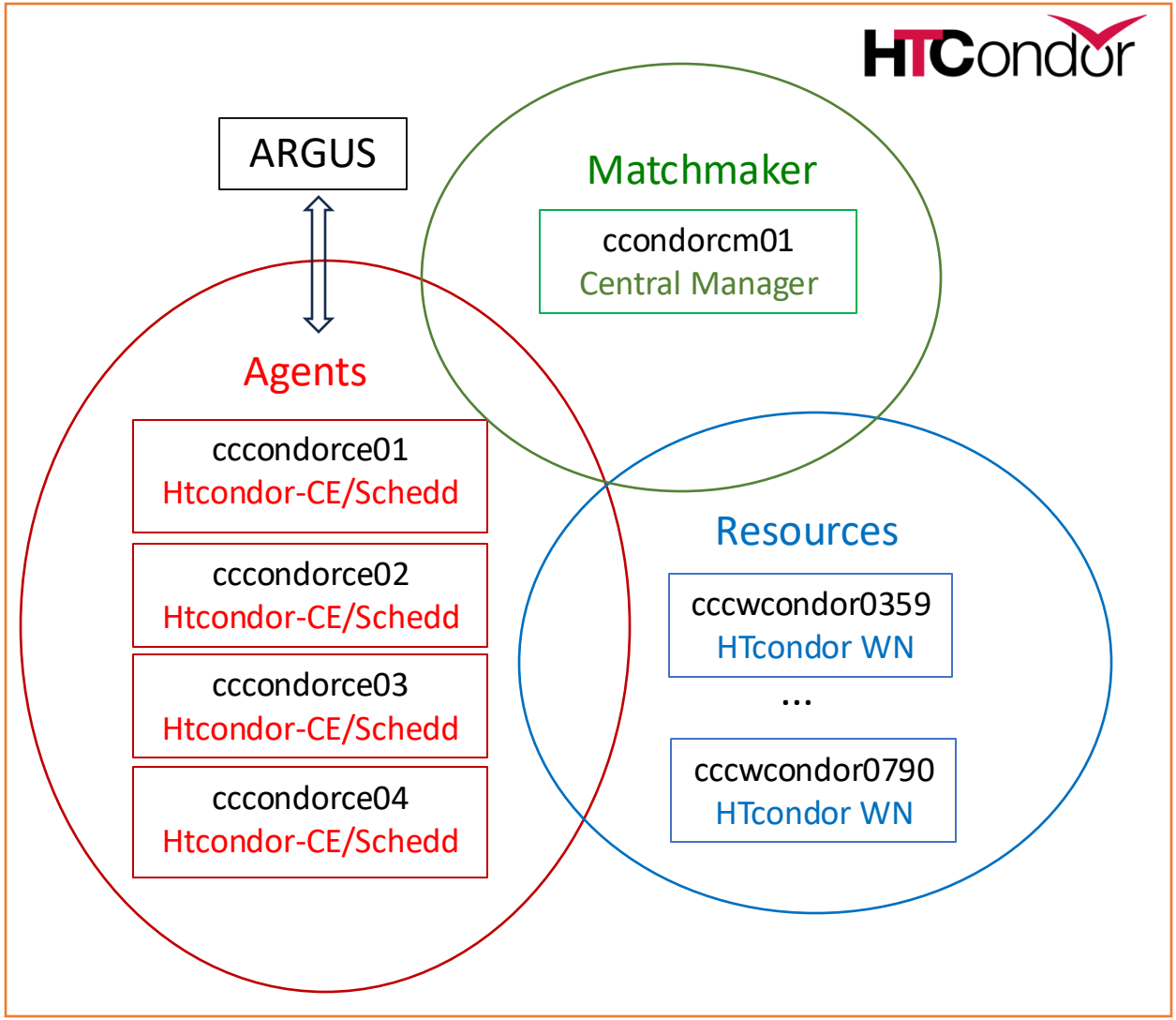


Exponential growth of computing/storage needs

CC-IN2P3: Computing Resources

- **HTCondor manages WLCG/EGI jobs:**
  - Versions:
    - HTCondor 23.10.1
    - HTcondorCE 23.9.1
  - 4 HTCondor CEs, 384 Worker Nodes on RHEL9
  - 32k slots & 497 kHS23 installed
  - Current users: ATLAS, CMS, ALICE, LHCb, Belle II, Dune, Virgo

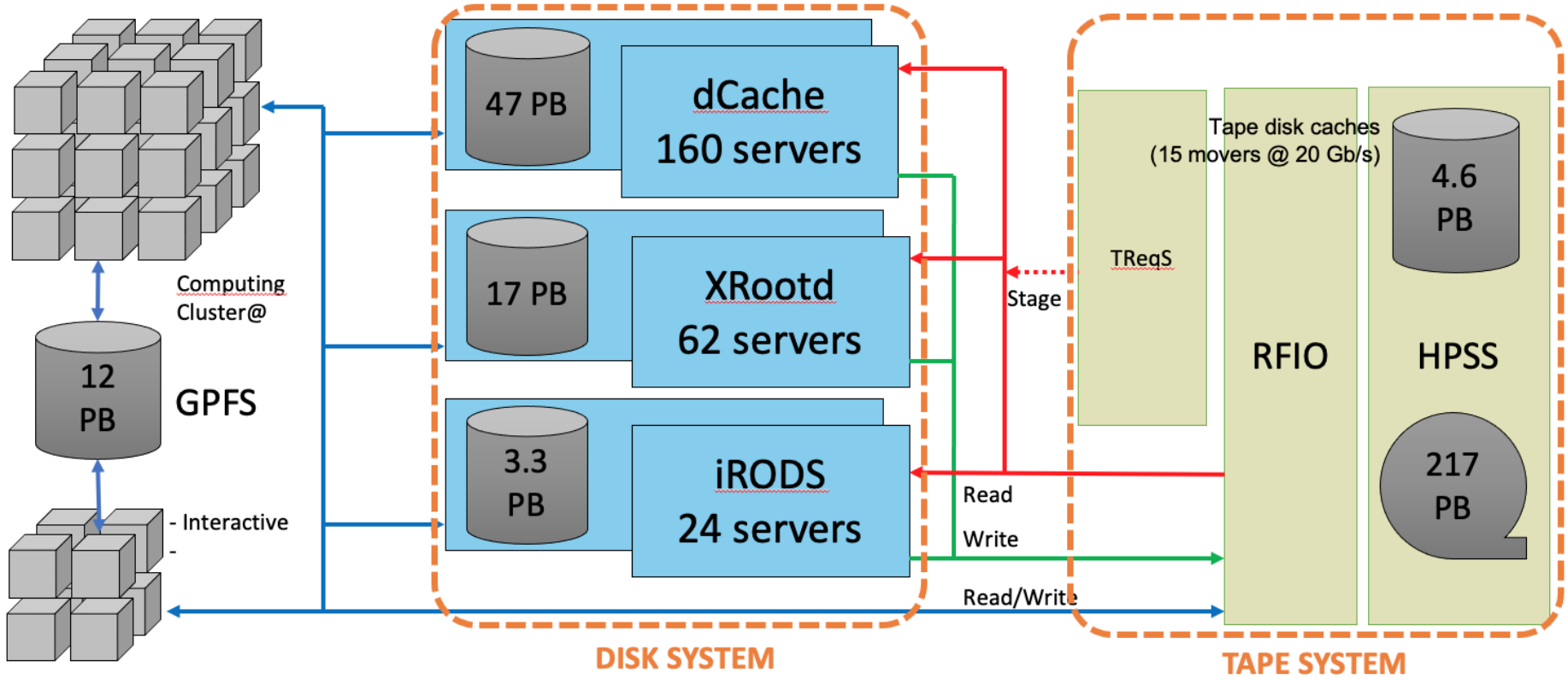
- **Slurm manages site jobs, HPC, GPGPU:**
  - Version: 24.05.4
  - 329 Worker Nodes on RHEL9
  - 25k slots & 408 kHS23 installed
  - 72 Nvidia V100 GPUs
  - Current users: ~50 groups



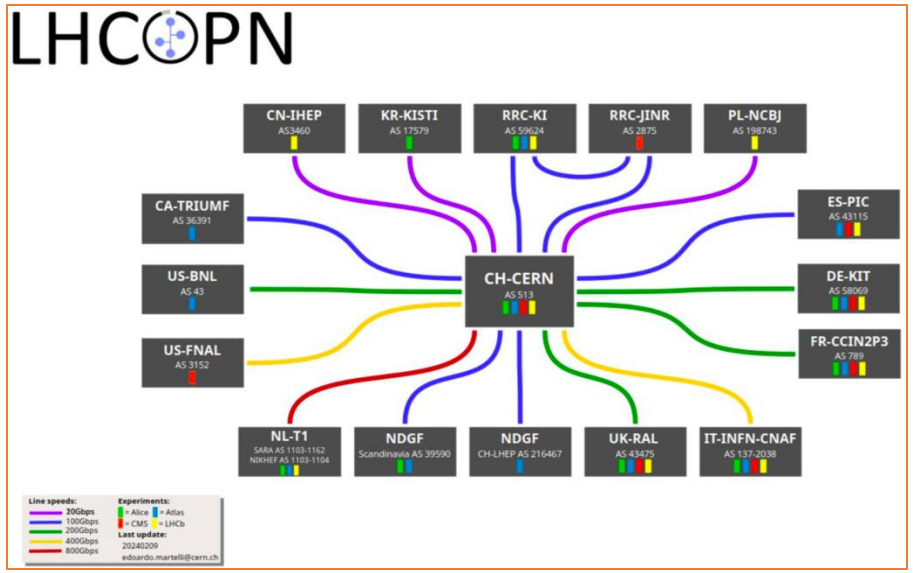
CC-IN2P3: Storage Resources

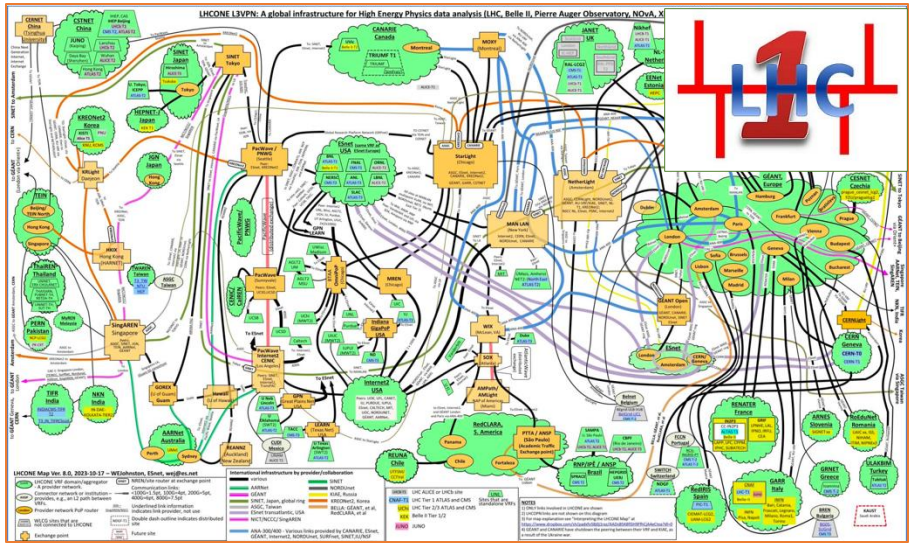
- dCache v9.2 (supporting Tape REST API for staging)
- 2 instances: LCG / EGEE
- LCG: 44PB split over 14 pools (avg 370 mover per pool)
  - Protocols: xrootd (WN<->DISK), https/dav (DISK<->DISK)
  - Current Users: ATLAS, CMS, LHCb
- EGEE: 3PB split over 21 pools (avg 450 mover per pool)

- HPSS v10.3
- 2 Spectra Tfinity Libraries with 2-armed robots
- 6800 slots per library and 20TB/slot
- 48 IBM TS1160 tape drives per library at 400MB/s
- Current Users: 80 experiments (including LHCb)



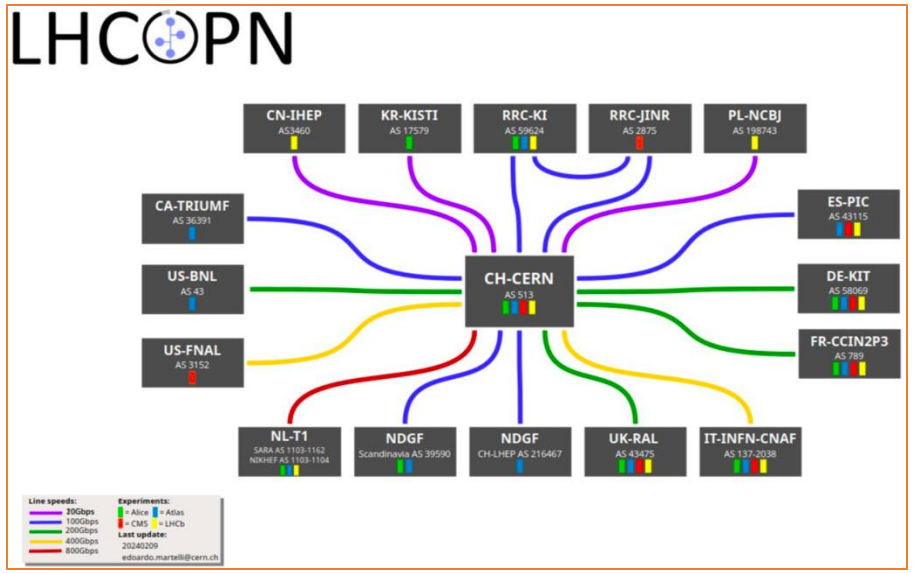
CC-IN2P3: Network (1/2)

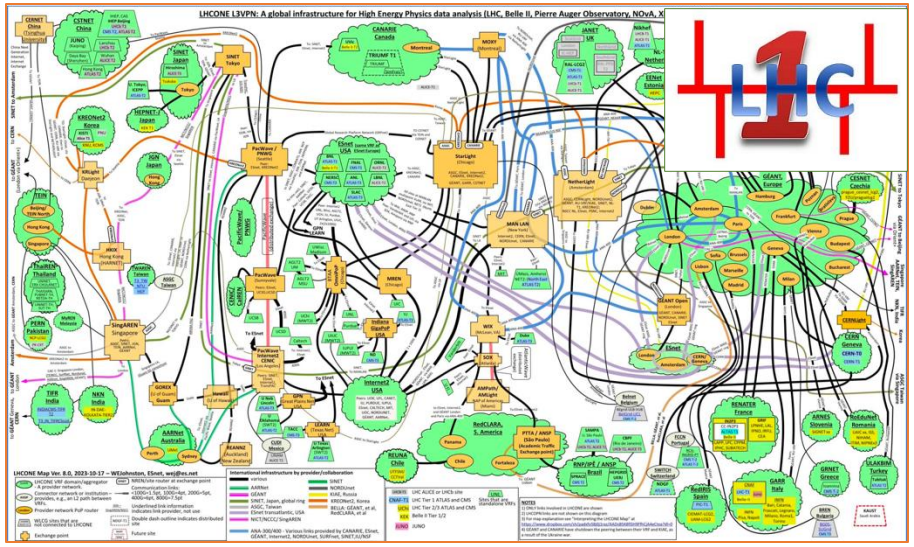




Bandwidth 200Gb/s for each LHCOPN and LHCONE link (400Gb/s foreseen in 2028)

CC-IN2P3: Network (2/2)





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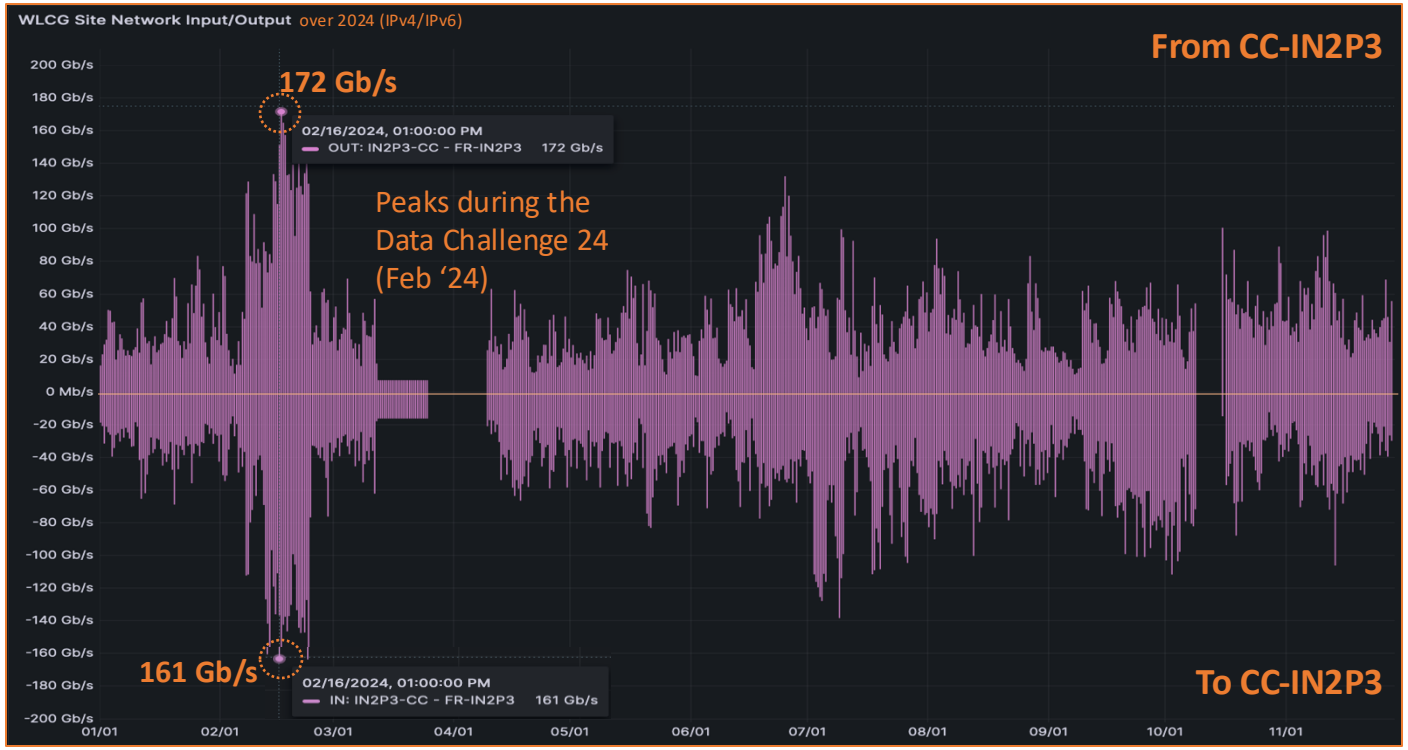


LHCb views on CC-IN2P3 Tier1

CCIN2P3 pledges to LHCb in 2024

CPU

Federation	Country	Pledge
UK-T1-RAL	United Kingdom	180519 HEPscore23
IT-INFN-CNAF	Italy	113430 HEPscore23
DE-KIT	Germany	95524 HEPscore23
CN-IHEP-T1	China	87000 HEPscore23
FR-CCIN2P3	France	84840 HEPscore23
PL-T1-NCBJ	Poland	63000 HEPscore23
NL-T1	Netherlands	45100 HEPscore23
ES-PIC	Spain	22880 HEPscore23
NRC-KI-T1	Russian Federation	0 HEPscore23

12% of all T1s

DISK

Federation	Country	Pledge
UK-T1-RAL	United Kingdom	15724 TBytes
IT-INFN-CNAF	Italy	11561 TBytes
DE-KIT	Germany	10220 TBytes
FR-CCIN2P3	France	7833 TBytes
NL-T1	Netherlands	5200 TBytes
CN-IHEP-T1	China	3200 TBytes
ES-PIC	Spain	2448 TBytes
PL-T1-NCBJ	Poland	1500 TBytes
NRC-KI-T1	Russian Federation	0 TBytes

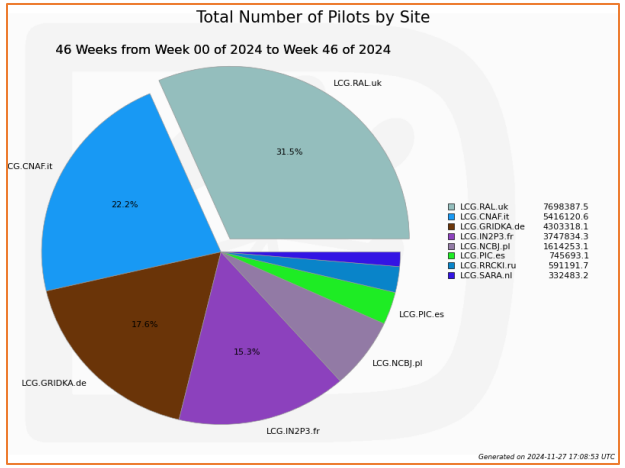
16% of all T1s

TAPE

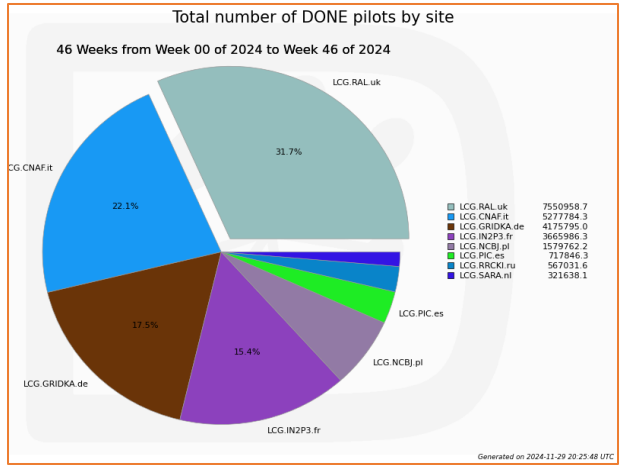
Federation	Country	Pledge
UK-T1-RAL	United Kingdom	39890 TBytes
IT-INFN-CNAF	Italy	25261 TBytes
DE-KIT	Germany	22262 TBytes
FR-CCIN2P3	France	20410 TBytes
NL-T1	Netherlands	12000 TBytes
ES-PIC	Spain	5332 TBytes
PL-T1-NCBJ	Poland	5000 TBytes
CN-IHEP-T1	China	3000 TBytes
NRC-KI-T1	Russian Federation	0 TBytes

15% of all T1s

LHCb Pilot & Wall Clock Time Distribution (1/3)

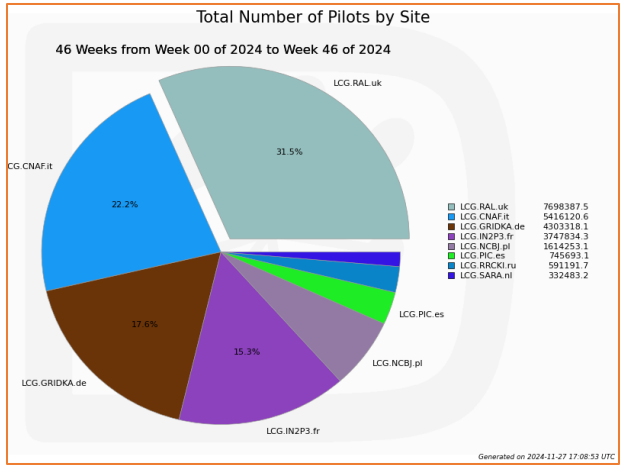


CC-IN2P3 represents
15.4% of **TOTAL** pilots

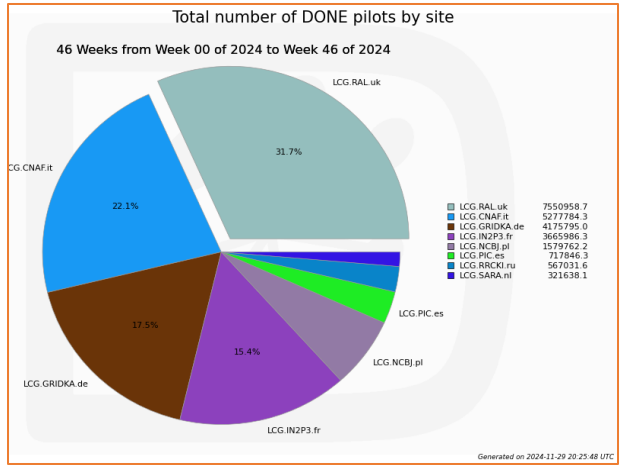


CC-IN2P3 represents
15.4% of **DONE** pilots

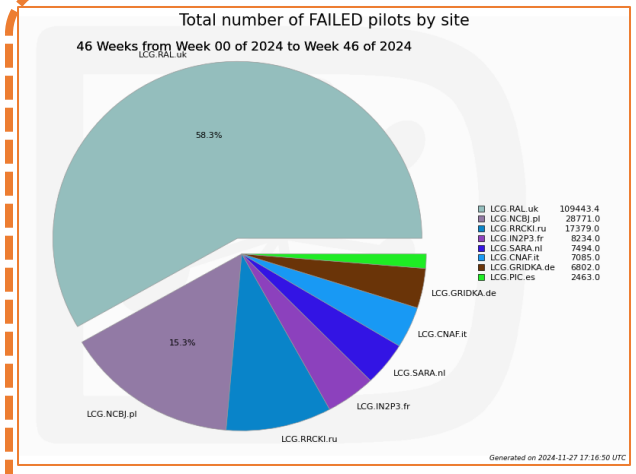
LHCb Pilot & Wall Clock Time Distribution (2/3)



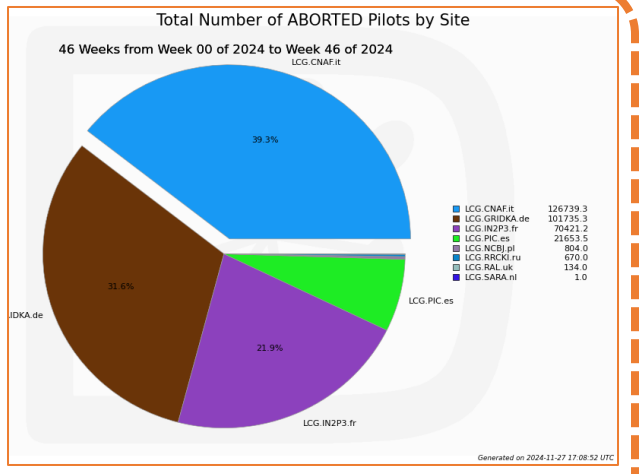
CC-IN2P3 represents
15.4% of **TOTAL** pilots



CC-IN2P3 represents
15.4% of **DONE** pilots

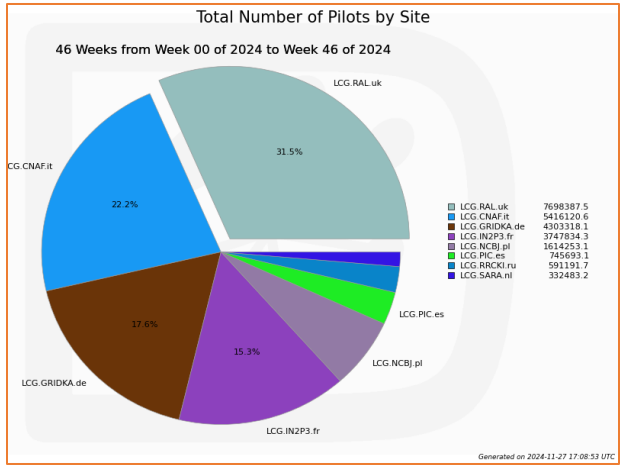


CC-IN2P3 represents
4.3% of **FAILED** pilots

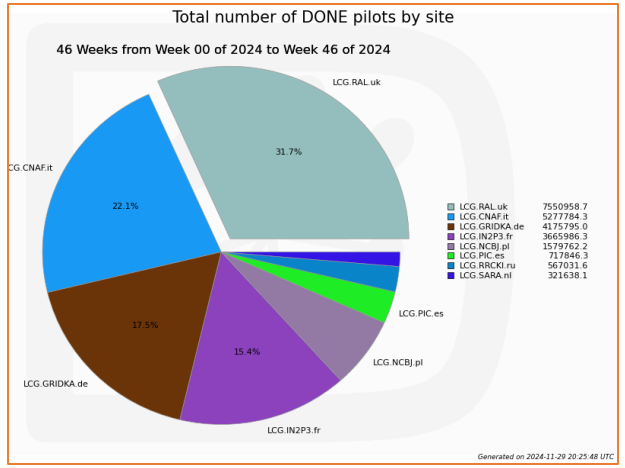


CC-IN2P3 represents
21.9% of **ABORTED** pilots

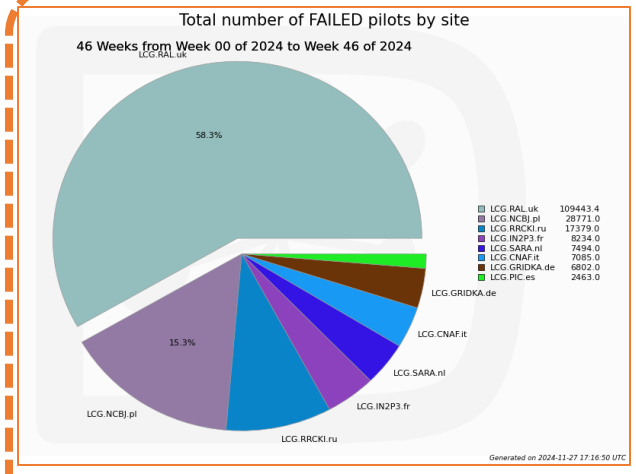
LHCb Pilot & Wall Clock Time Distribution (3/3)



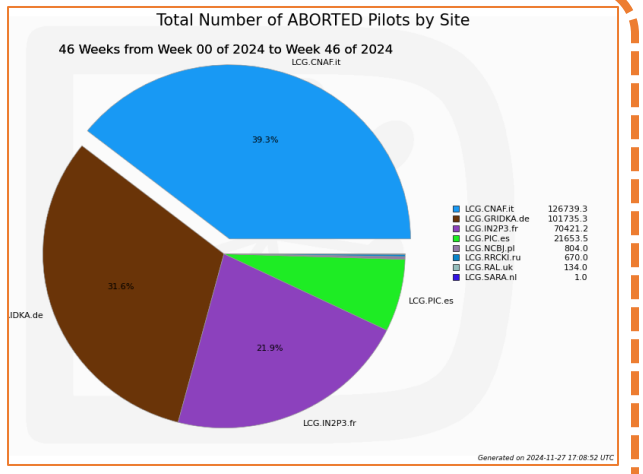
CC-IN2P3 represents
15.4% of **TOTAL** pilots



CC-IN2P3 represents
15.4% of **DONE** pilots



CC-IN2P3 represents
4.3% of **FAILED** pilots



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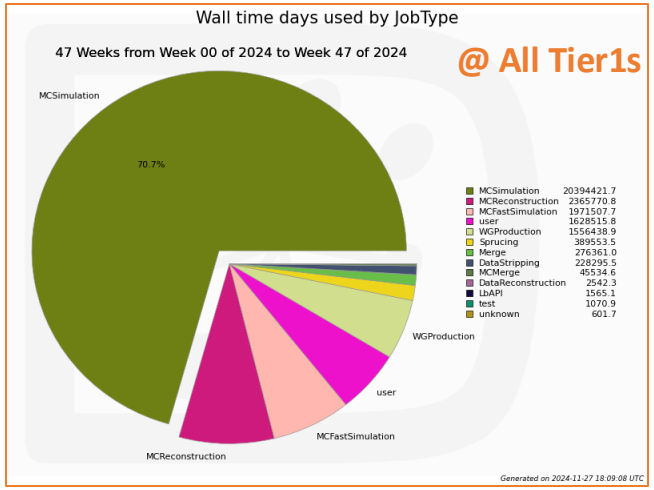
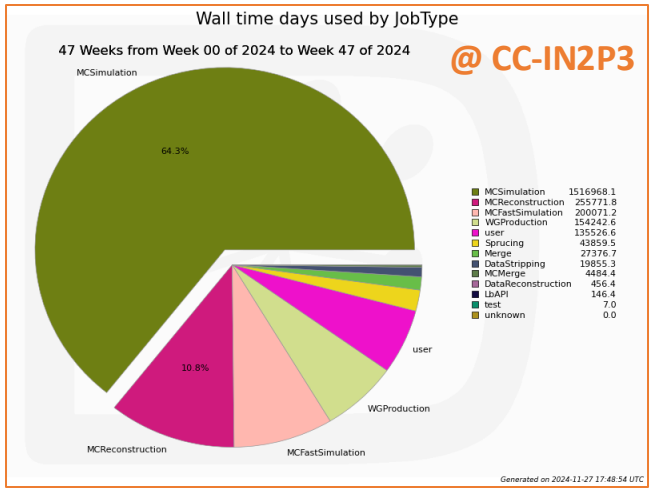
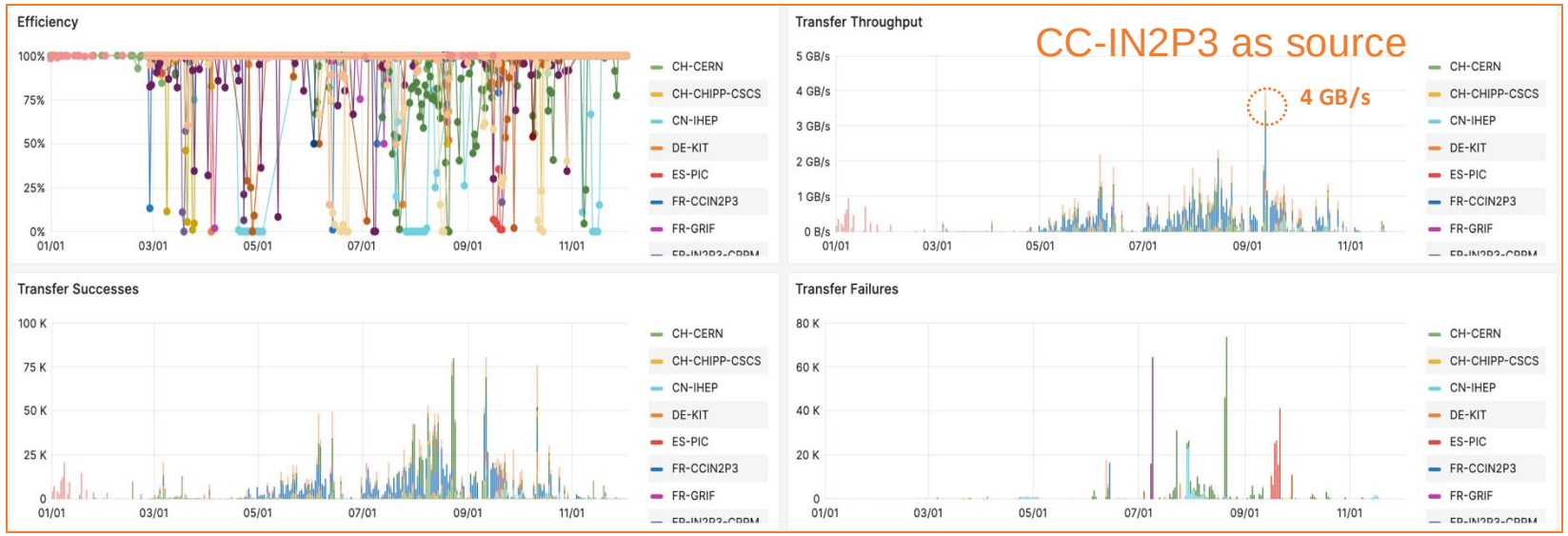


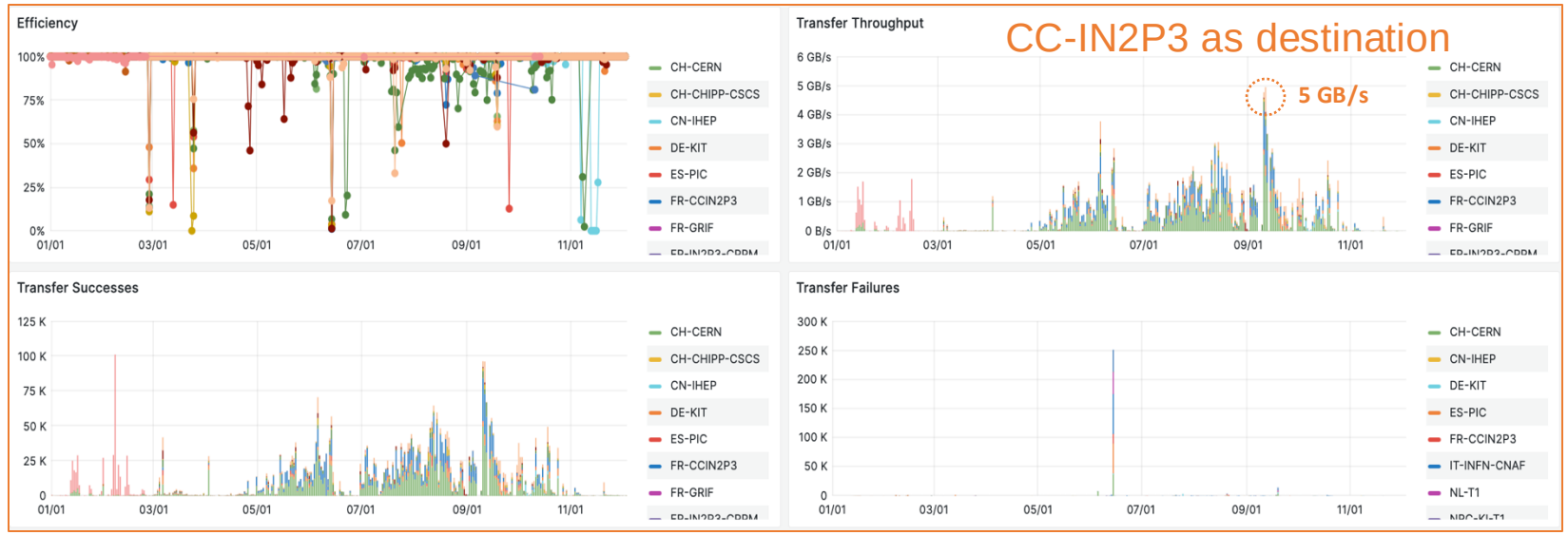


More than ¾ of total
wall clock time for
MC production

LHCb Data Distribution (1/2)

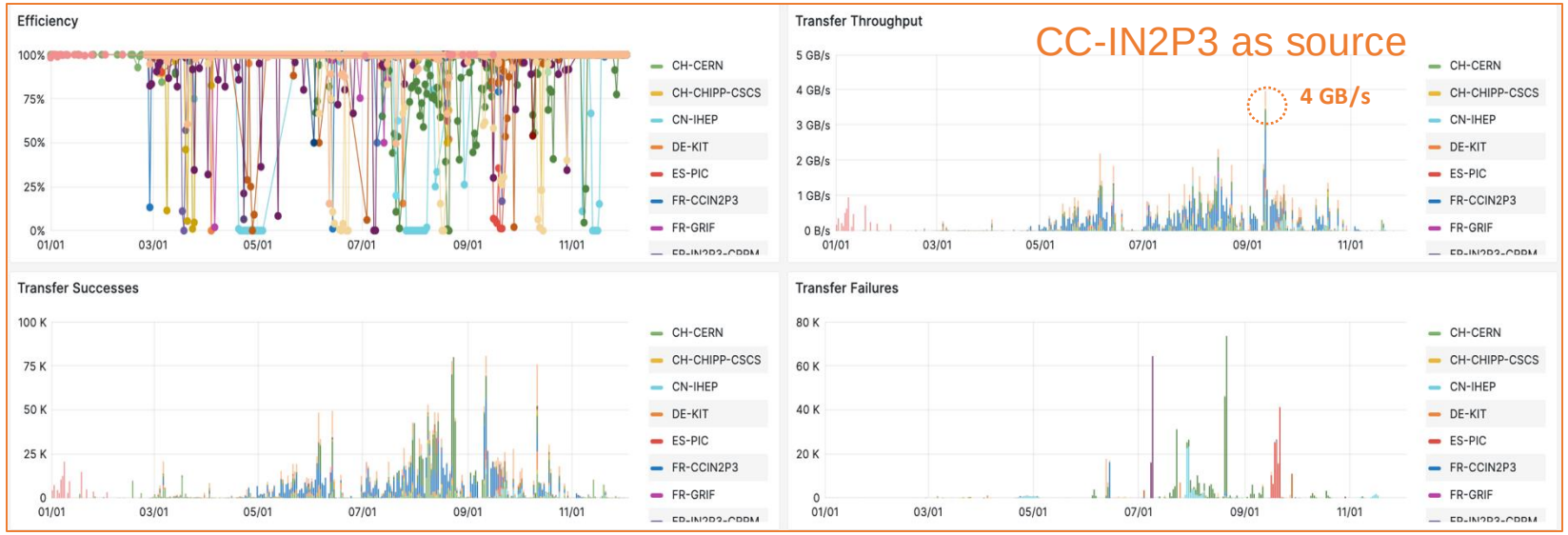
FTS TRANSFERS

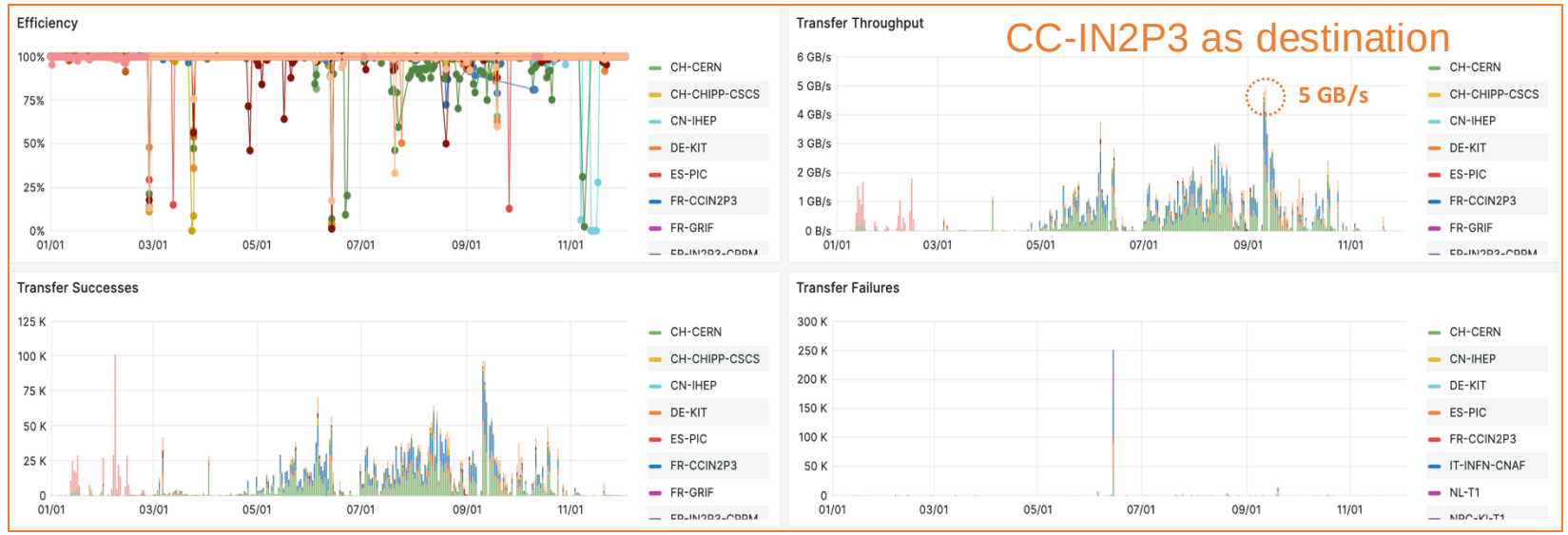




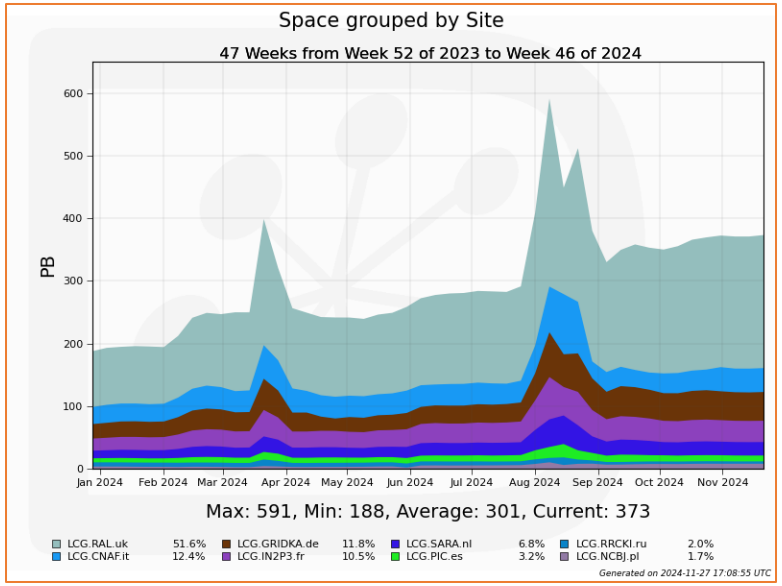
LHCb Data Distribution (2/2)

FTS TRANSFERS





DISK SPACE OCCUPANCY



CC-IN2P3 Tier1 views on LHCb

IN2P3 contributions to LHCb

- **Data centers:**
  - **Tier-1:**
    - **CC-IN2P3 (Lyon)**
  - Tier-2s:
    - CPPM (Marseille)
    - IJCLab (Orsay)
    - LAPP (Annecy)
    - LLR (Palaiseau)
    - LPCA (Clermont-Ferrand)
    - LPNHE (Paris)

IN2P3
Data Centers

IN2P3 CONTRIBUTIONS

- Front-end and mechanical electronics for the calorimeters and for the stack detector.
- A first-level triggering system that reduces the number of collisions from 40 to 1 million per second and searches for large transverse momentum electrons, muons and photons in less than a microsecond for each collision.
- Detector upgrade for the LHC Run 3 in 2022: reconstruction and filtering of all collisions in real time at 40Tb/s, the development of very high-speed acquisition cards, information processing on heterogeneous computing architectures (CPU + GPU); the PLUME luminometer.
- DIRAC software package for distributing collision reconstruction and simulation on the WLCG computing grid.
- SciFi detector: PACIFIC ASIC, box for front-end boards, back-end electronics and its firmware, cooling.

Scientific leader: Renaud Le Gac (CPPM)

CC-IN2P3 Resources for LHCb

- PLEDGED RESOURCES

Federation	Tier	VO	Year	Type	Pledge	
FR-CCIN2P3	1	LHCb	2024	CPU	84840 HEPscore23	18% of all LHC VOs
FR-CCIN2P3	1	LHCb	2024	Disk	7833 TBytes	15% of all LHC VOs
FR-CCIN2P3	1	LHCb	2024	Tape	20410 TBytes	14% of all LHC VOs

- JOB & TRANSFER ENDPOINTS:
  - HTCondor (max 8k running slots):
    - cccondorce0[1-4].in2p3.fr
    - Token based job submission
  - dCache:
    - ccdavlhcb-tape.in2p3.fr
    - ccdavlhcb.in2p3.fr
- VOBOX:
  - Migration to EL9 and config to support FQDN (for “lcgadmin”)
    - https://twiki.cern.ch/twiki/bin/view/LCG/WLCGvoboxDeployment
    - https://ggus.eu/index.php?mode=ticket_info&ticket_id=168907
    - https://ggus.eu/index.php?mode=ticket_info&ticket_id=168908
- SUPPORT:
  - cc-lhcb@cc.in2p3.fr

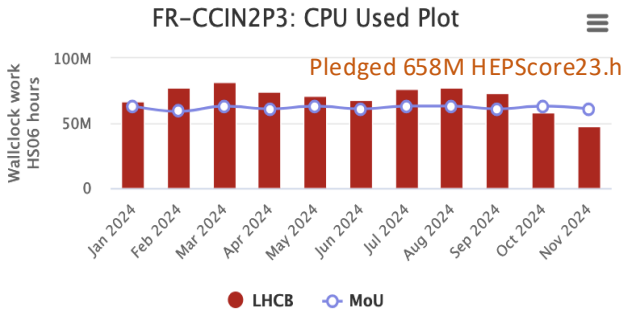
OTHER LHC VOs’ pledges @CC-IN2P3

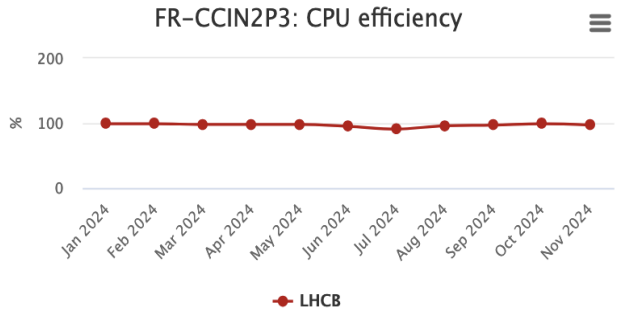
Edit	Federation	Tier	VO	Year	Type	Pledge
	FR-CCIN2P3	1	ATLAS	2024	CPU	204660 HEPscore23
	FR-CCIN2P3	1	ATLAS	2024	Disk	22005 TBytes
	FR-CCIN2P3	1	ATLAS	2024	Tape	65540 TBytes

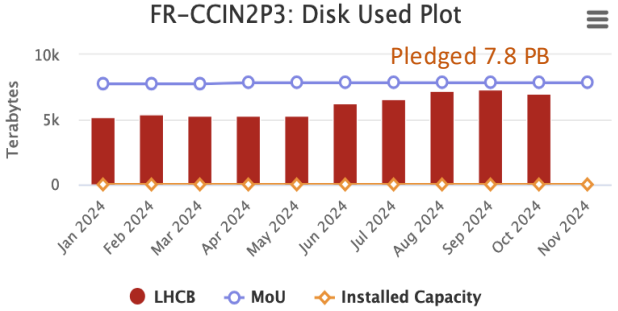
Edit	Federation	Tier	VO	Year	Type	Pledge
	FR-CCIN2P3	1	CMS	2024	CPU	93930 HEPscore23
	FR-CCIN2P3	1	CMS	2024	Disk	12808 TBytes
	FR-CCIN2P3	1	CMS	2024	Tape	39900 TBytes

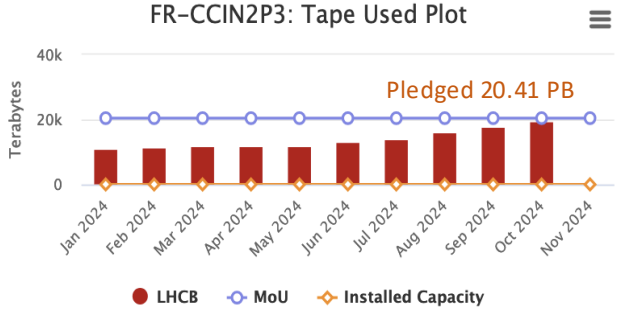
Edit	Federation	Tier	VO	Year	Type	Pledge
	FR-CCIN2P3	1	ALICE	2024	CPU	70560 HEPscore23
	FR-CCIN2P3	1	ALICE	2024	Disk	8938 TBytes
	FR-CCIN2P3	1	ALICE	2024	Tape	16087 TBytes

LHCb @CC-IN2P3: Pledges vs Consumption (1/2)

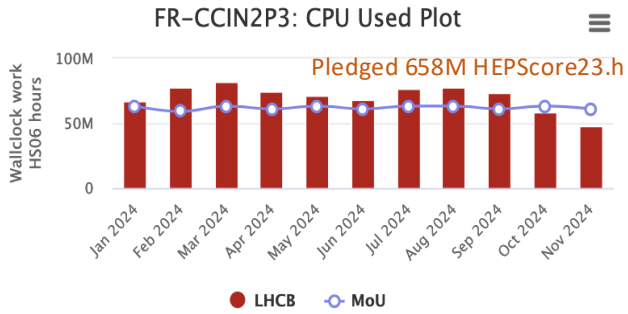


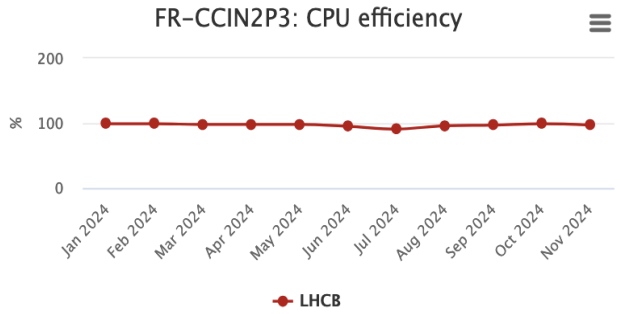


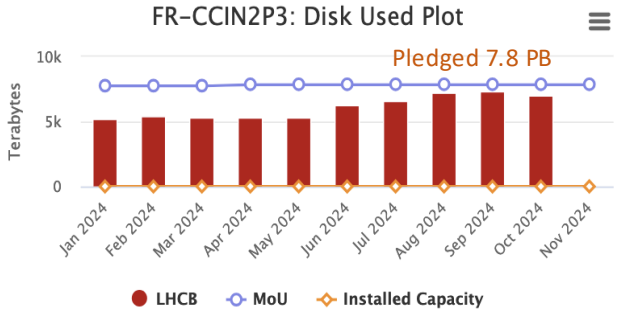


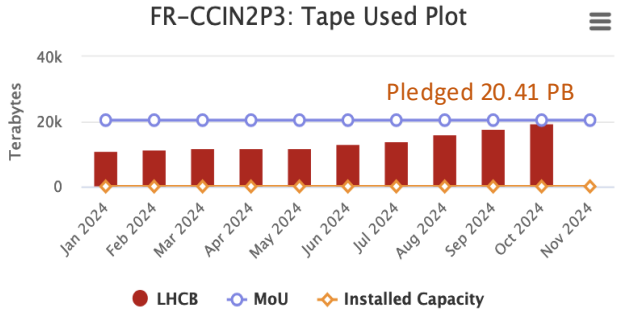


LHCb @CC-IN2P3: Pledges vs Consumption (2/2)

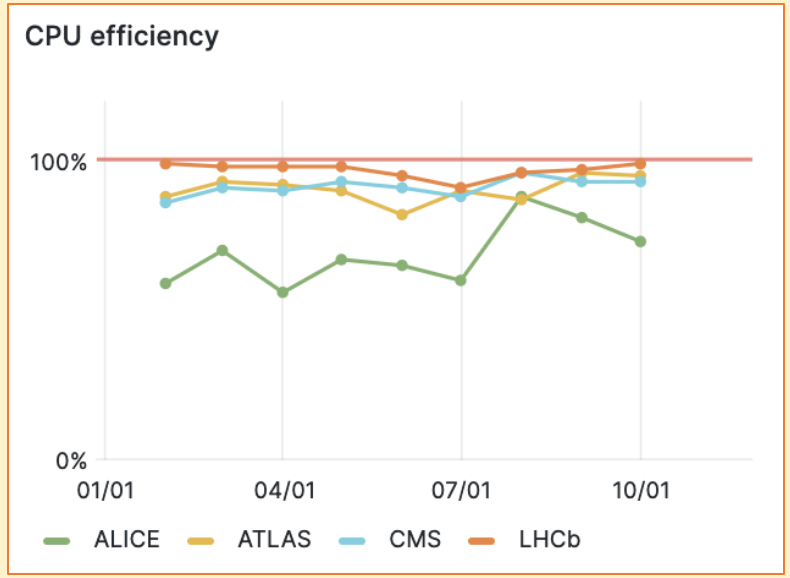








LHCB VS OTHER LHC VOs



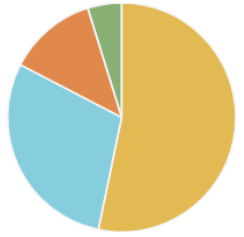
Wall-Clock Time (in hours)

	total	percentage
ATLAS	97 Mil	46%
LHCb	47 Mil	22%
CMS	46 Mil	22%
ALICE	19 Mil	9%

Disk Used

	total	percentage
ATLAS	21 PB	46%
ALICE	9 PB	20%
CMS	9 PB	20%
LHCb	6 PB	14%

Tape Used

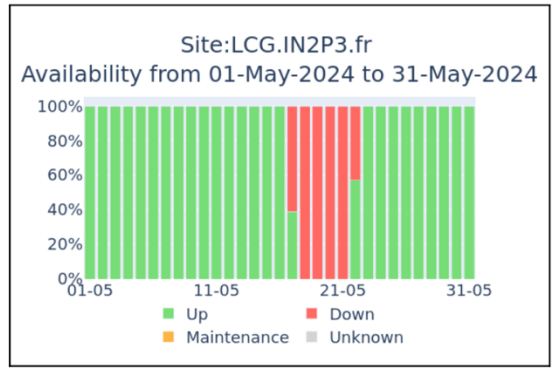


	used	percentage
ATLAS	59 PB	53%
CMS	32 PB	29%
LHCb	14 PB	13%
ALICE	5 PB	5%

Issues & challenges

LHCb's Issues @CC-IN2P3

- Site Availability and Reliability ranges between 99% and 100% in 2024
  - Except for May 2024 where CC-IN2P3 dropped to the dual stack network configuration migrating of our HTCondor farm (a Down Time was needed?)



LCG.IN2P3.fr Avail: 84.0% Unkn: 0%

- GGUS Tickets:
  - Service configuration: storage (token) and VOBOX (EL9 and "lcgadmin" access)
  - Running pilots: lower computing farm capacity and aborted pilots
  - Transfers: storage system overload & other issues

  More recurrent
  - Network: external network hardware issue (Renater router)
  - Data Challenge: tracing issues & coordinating fixes

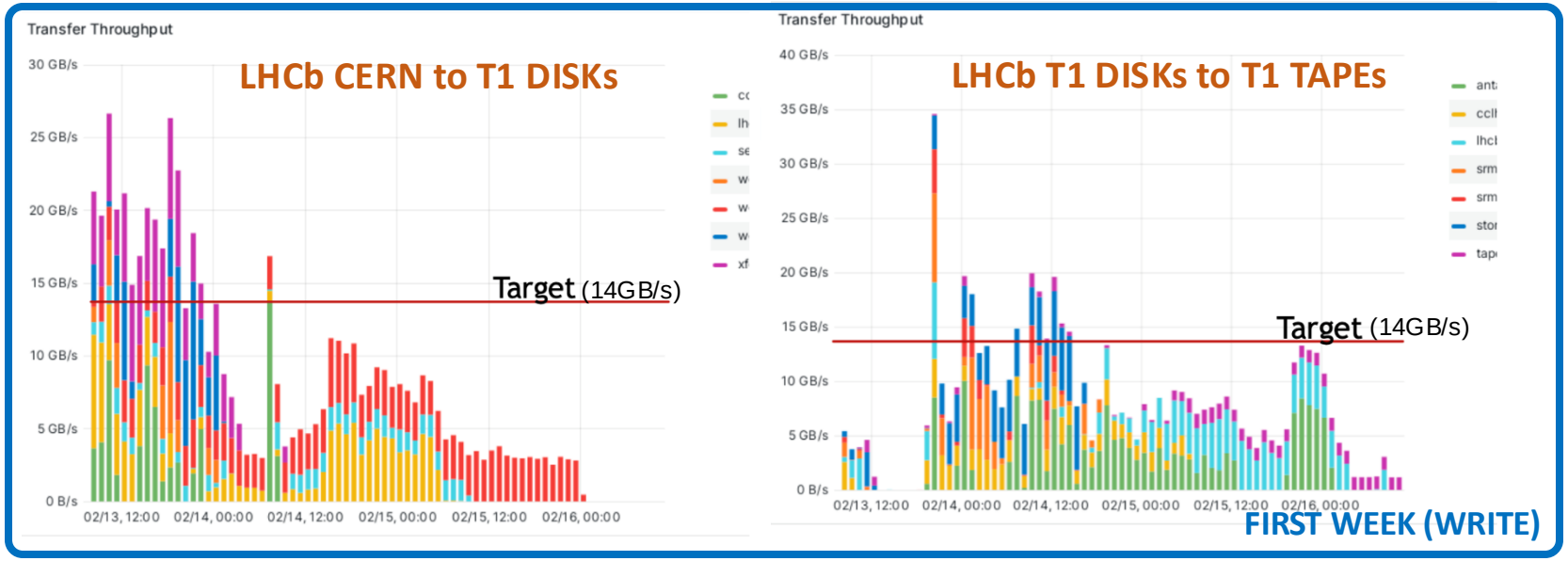
11 of 11 Tickets

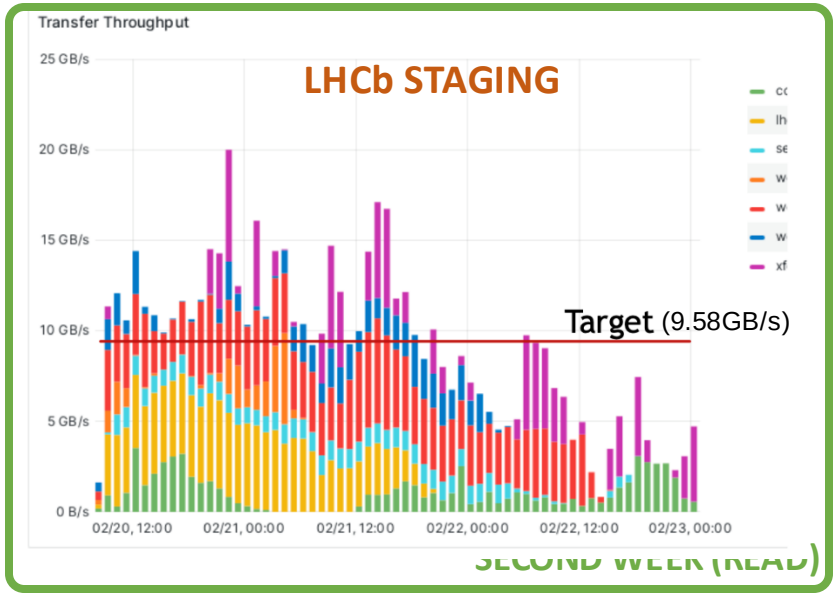
Ticket-ID	Type	VO	Site	Priority	Resp. Unit	Status	Last Update	Subject	Scope	
168907	Team	lhcb	IN2P3-CC	less urgent	NGI_FRANCE	in progress	2024-11-25	Access to the T1 vobox	WLCG	
168808	Team	lhcb	IN2P3-CC	very urgent	NGI_FRANCE	verified	2024-10-29	Running jobs at IN2P3-CC	WLCG	
168009	Team	lhcb	IN2P3-CC	top priority	NGI_FRANCE	closed	2024-09-18	Wrong alias removed ?	WLCG	
167891	Team	lhcb	IN2P3-CC	urgent	NGI_FRANCE	closed	2024-09-11	File access problems at IN2P3	WLCG	
167877	Team	lhcb	IN2P3-CC	very urgent	NGI_FRANCE	verified	2024-08-16	Failed transfers to/from IN2P3-BUFFER	WLCG	
167137	Team	lhcb	IN2P3-CC	very urgent	NGI_FRANCE	closed	2024-07-08	File has gone missing	WLCG	
167073	Team	lhcb	IN2P3-CC	very urgent	NGI_FRANCE	verified	2024-06-13	Data transfers failed at IN2P3-CC	WLCG	
166161	Team	lhcb	IN2P3-CC	very urgent	NGI_FRANCE	verified	2024-04-10	Pilots Aborted at IN2P3-CC	WLCG	
165226	Team	lhcb	IN2P3-CC	urgent	NGI_FRANCE	verified	2024-03-22	DC24: LHCb activity	WLCG	
165173	Team	lhcb	IN2P3-CC	very urgent	NGI_FRANCE	closed	2024-04-08	Tape Rest API	WLCG	
165050	Team	lhcb	IN2P3-CC	urgent	NGI_FRANCE	closed	2024-02-20	LHCb token authentication for disk ...	WLCG	

Service Configuration
Running Pilots
Transfers
Network
Data Challenge

N.B. Not all LHCb issues/requests @CC-IN2P3 are handled via GGUS.
Here other useful channels:
- Mail to lhcb-geoc@cern.ch
- LHCb Ops Meetings
- LHCb E-log: https://lblogbook.cern.ch/Operations/

Data Challenge ‘24





- Date: February 12 – February 25
- Participants: T0/1/2 sites & all 4 LHC VOs + Dune and Belle II
- Goals: to measure site-to-site transfer rates while aiming at reaching 25% of HL-LHC needs (i.e. 4.8Tbps for all VOs). But also to validate new services/functionalities (e.g. tokens)
  - LHCb only used tokens for CERN-to-Tier1 disk transfers (also @ CC-IN2P3)
- Outcome: global objectives achieved for all VOs despite some evident issues
  - IAM and FTS services (overload + incidents)
  - Site Issues with configuration and storage systems across multiple sites (e.g. LHCb tape buffer saturation @CC-IN2P3 during the tape recall, quickly fixed)

Targets, GB/s			Achieved, GB/s			Ratio (achieved/target)		
Site	Write	Stage	EOS-Disk	Disk-Tape	Tape-Disk	EOS-Disk	Disk-Tape	Tape-Disk
CNAF	2.05	1.60	3.45	2.74	1.41	1.68	1.34	0.88
GRIDKA	2.74	1.66	2.50	1.65	3.35	0.91	0.60	2.01
IN2P3	1.53	1.20	2.56	1.42	1.05	1.67	0.93	0.88
NCBJ	1.02	0.89	0.953	0.602	0.798	0.93	0.59	0.90
PIC	0.51	0.40	1.21	0.553	1.05	2.37	1.08	2.63
RAL	3.96	2.40	2.68	2.64	3.28	0.68	0.67	1.37
SARA	1.15	0.80	2.77	1.39	1.17	2.40	1.20	1.46

DC ‘24 RESULTS

Conclusions

- LHCb is one of the LHC experiments CC-IN2P3 supports in a context of high concurrency for computing and storage resources between LHC and non-LHC VOs
- CC-IN2P3 is amongst the 4 main contributors to LHCb Tier1 activities
- Overall operations are smooth with few/minor well known issues
- Margins of imprevement at storage level (config, functionalities, dimensioning)
- LHCb is the least demanding in terms of resource requirements wrt other LHC VOs for CC-IN2P3 but its requirements are expected to critically rise in the next years

MERCI !

BACKUP SLIDES

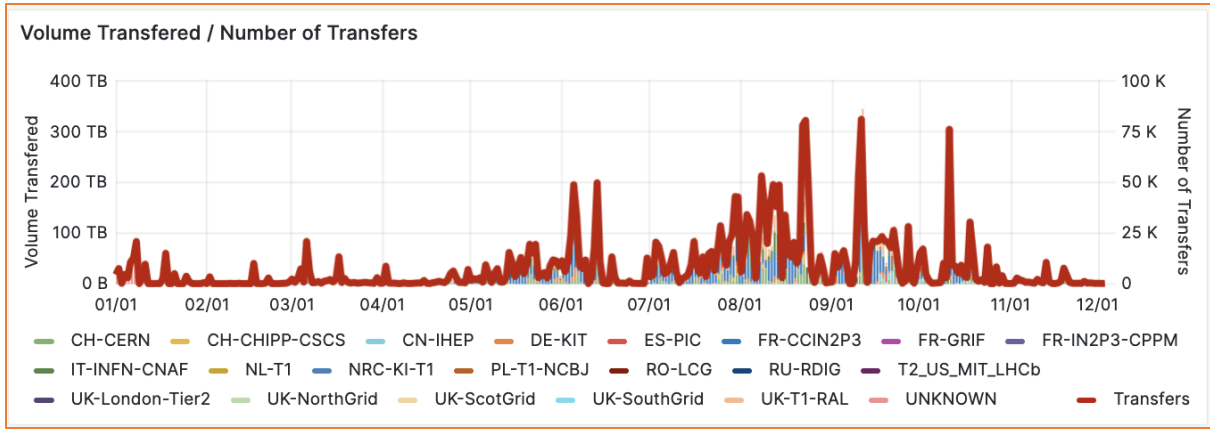
Links about LHCb pledges

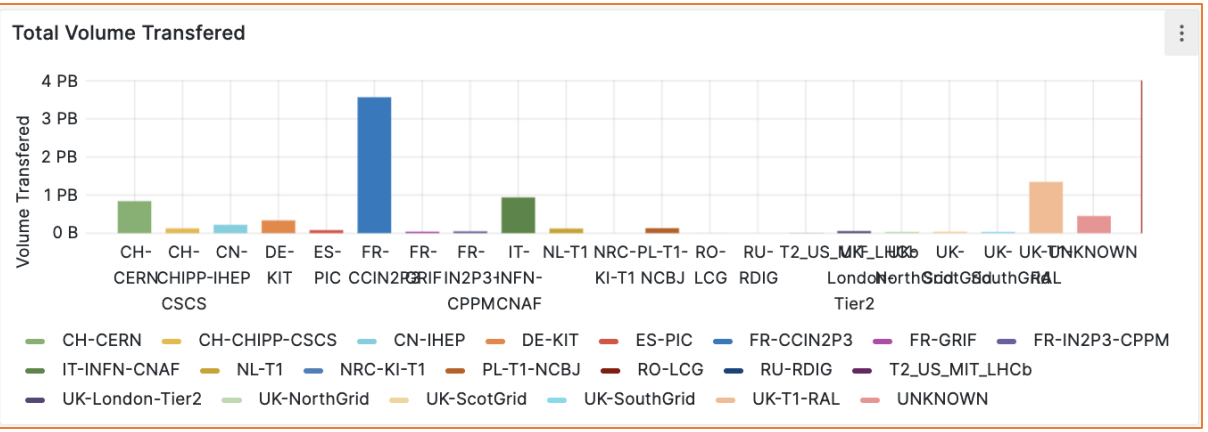
- LHCb pledges:
  - “LHCb Computing Resources - 2025 requests” (31.01.24) : https://cds.cern.ch/record/2888939/files/LHCb-PUB-2024-002.pdf
  - “Pledges vs Requirements per VO” (30.11.24) : https://wlcg-cric.cern.ch/core/vopledgereq/listcomp/

- WLCG debate over Bearer Tokens:
  - https://indico.cern.ch/event/1471694/

FTS Transfer Volumes for LHCb @ CC-IN2P3

CC-IN2P3 as source





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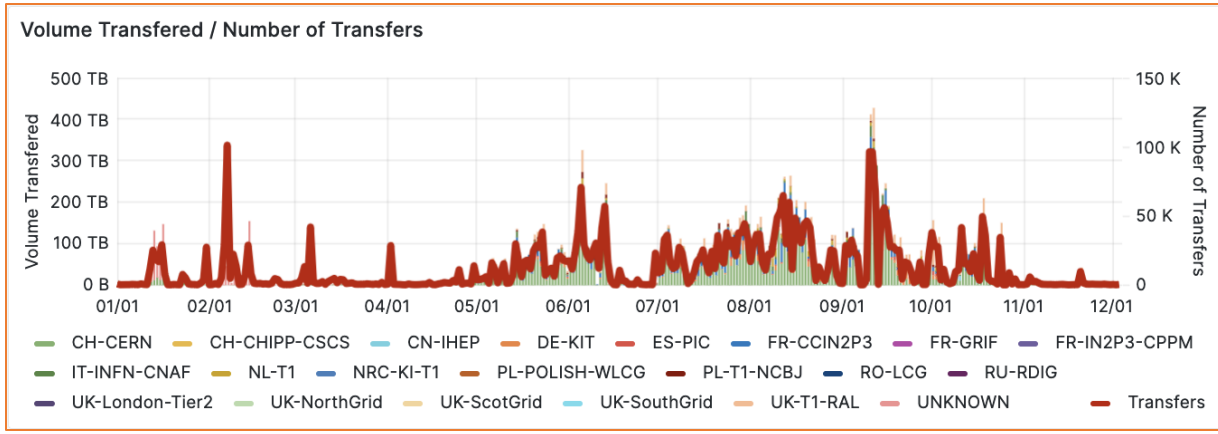
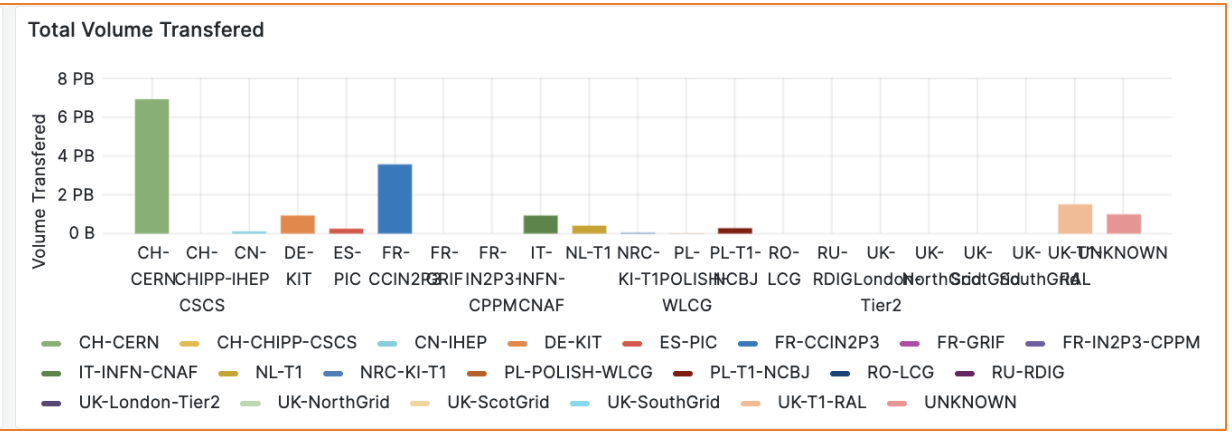
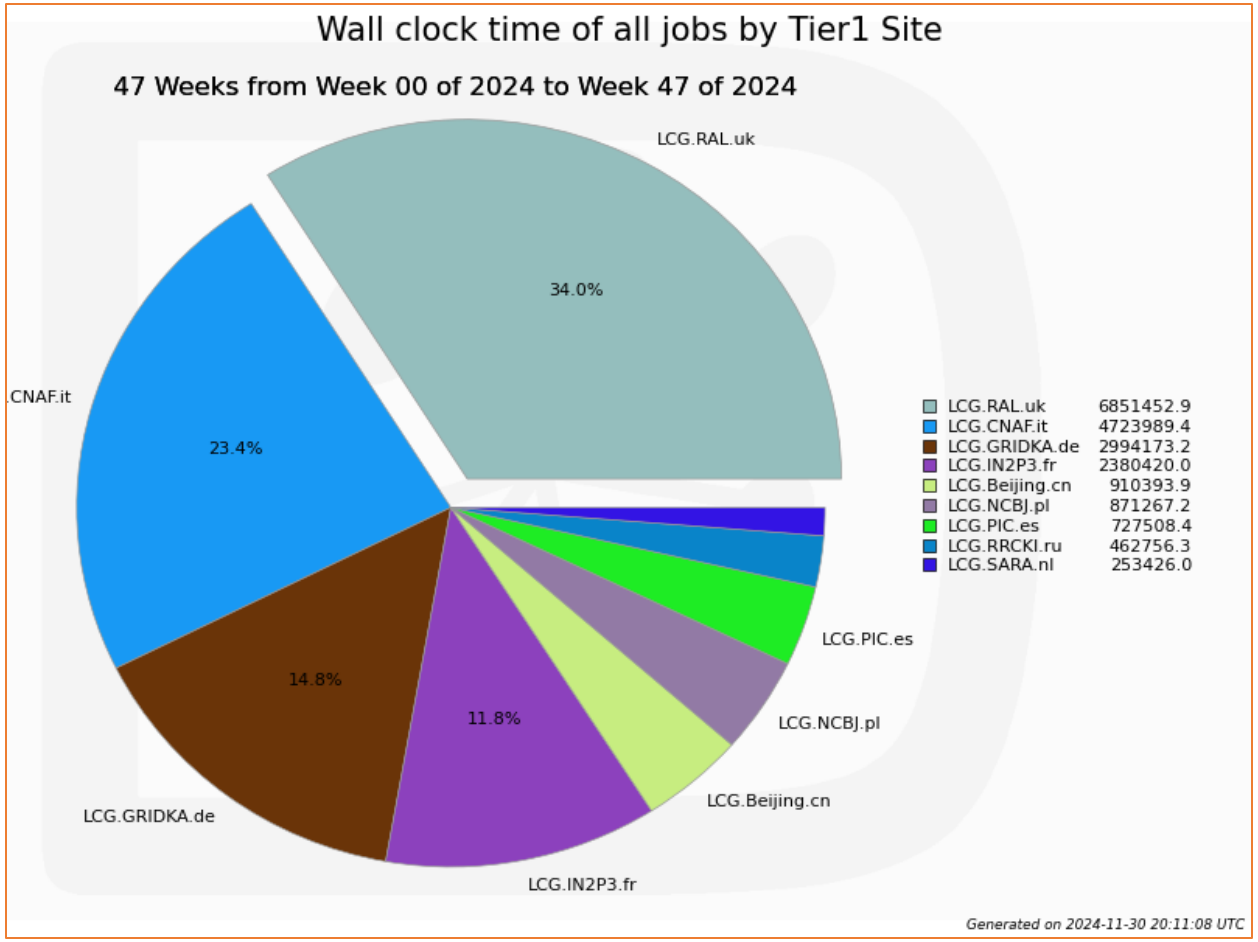
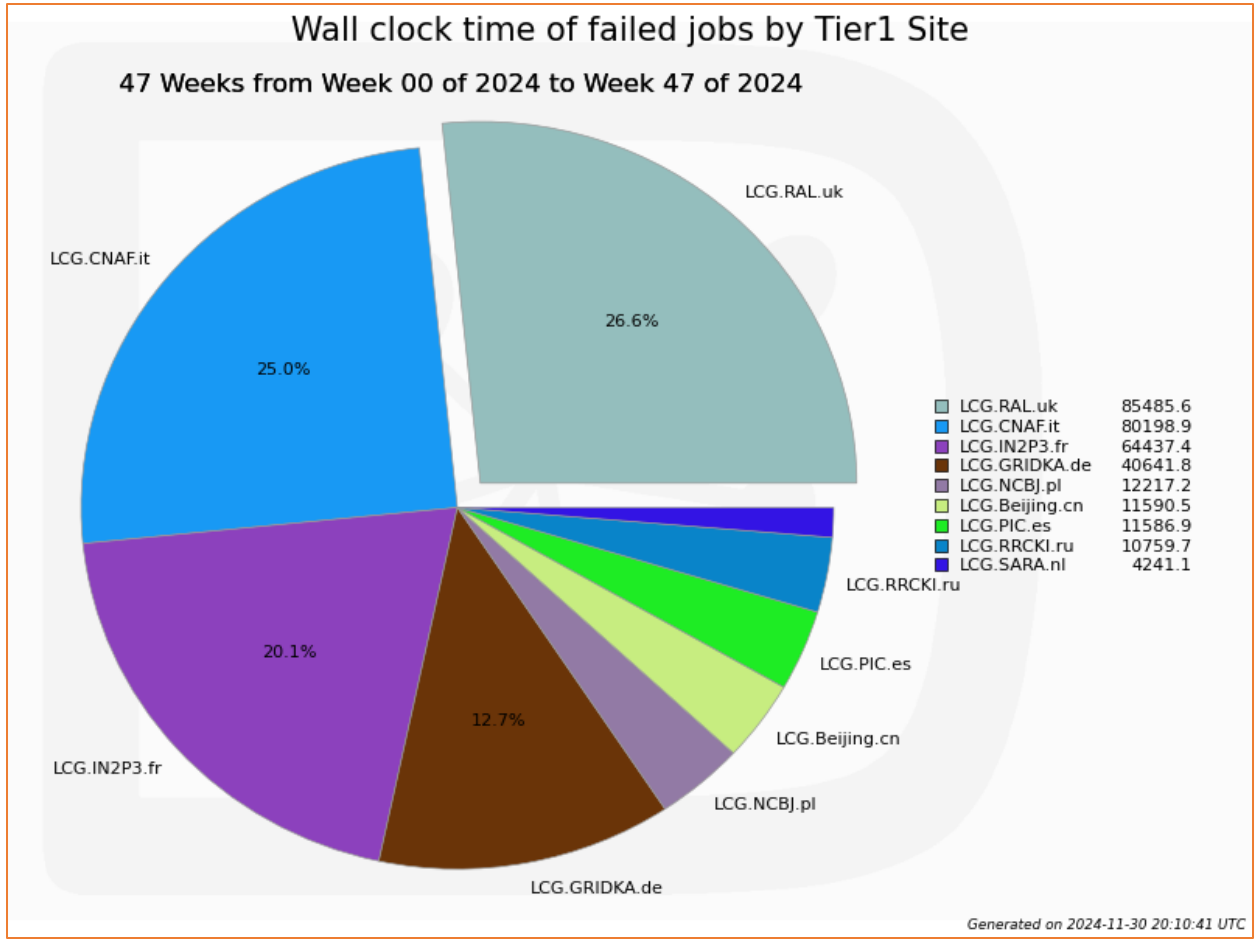


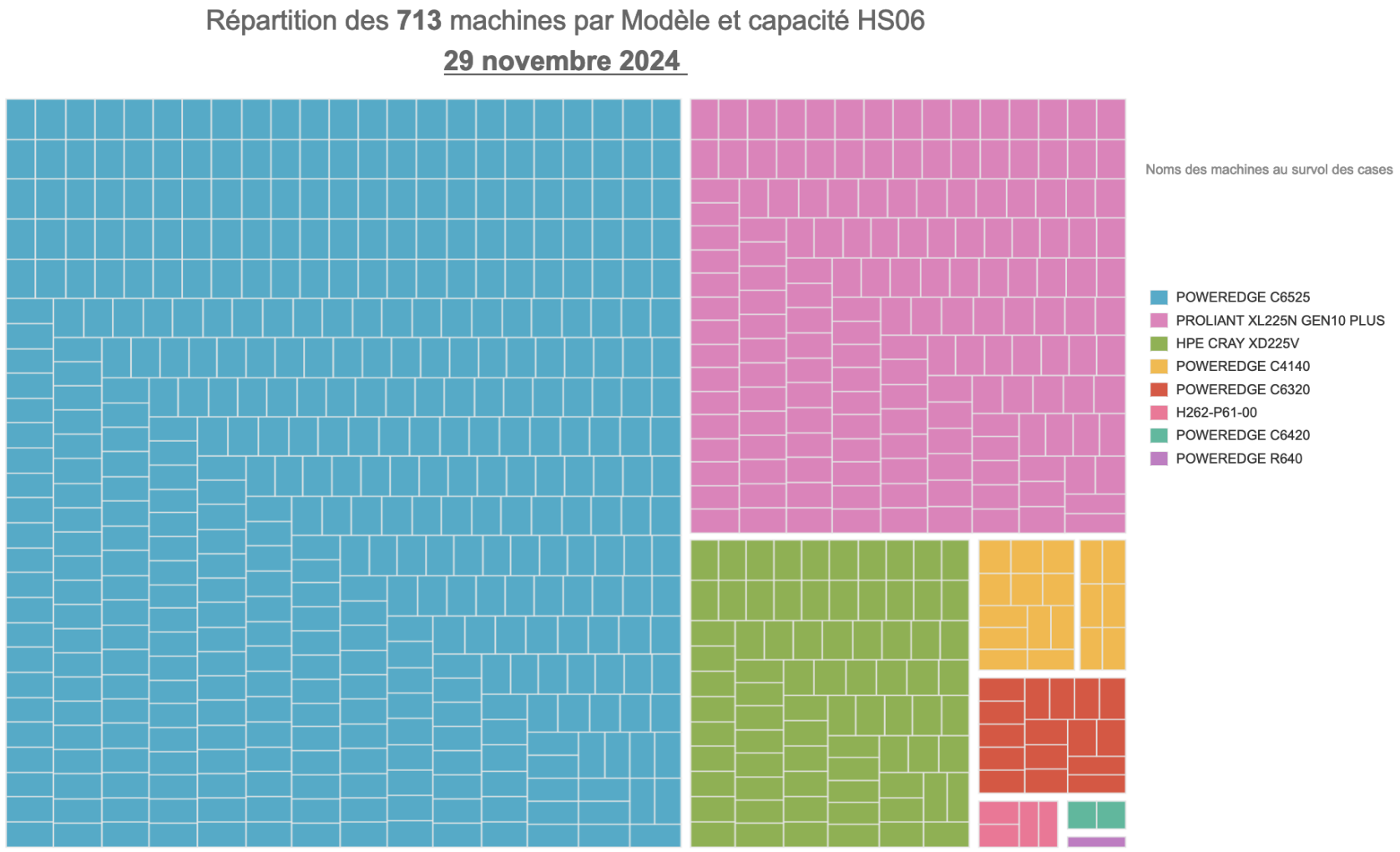
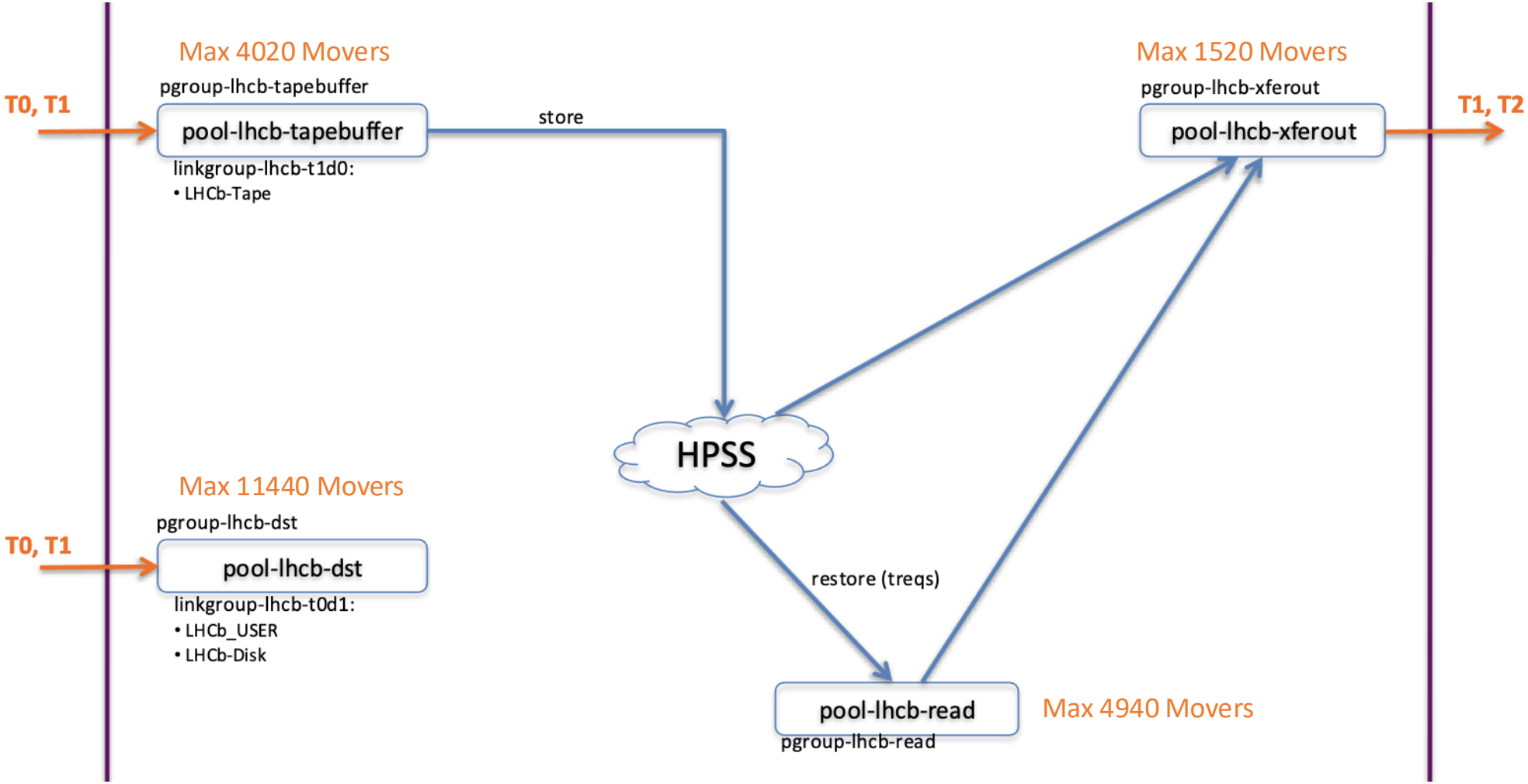


LHCb Wall Clock Time Distribution by Tier1 site





Types of Computing Machines @ CC-IN2P3



dCache Pool Topology for LHCb