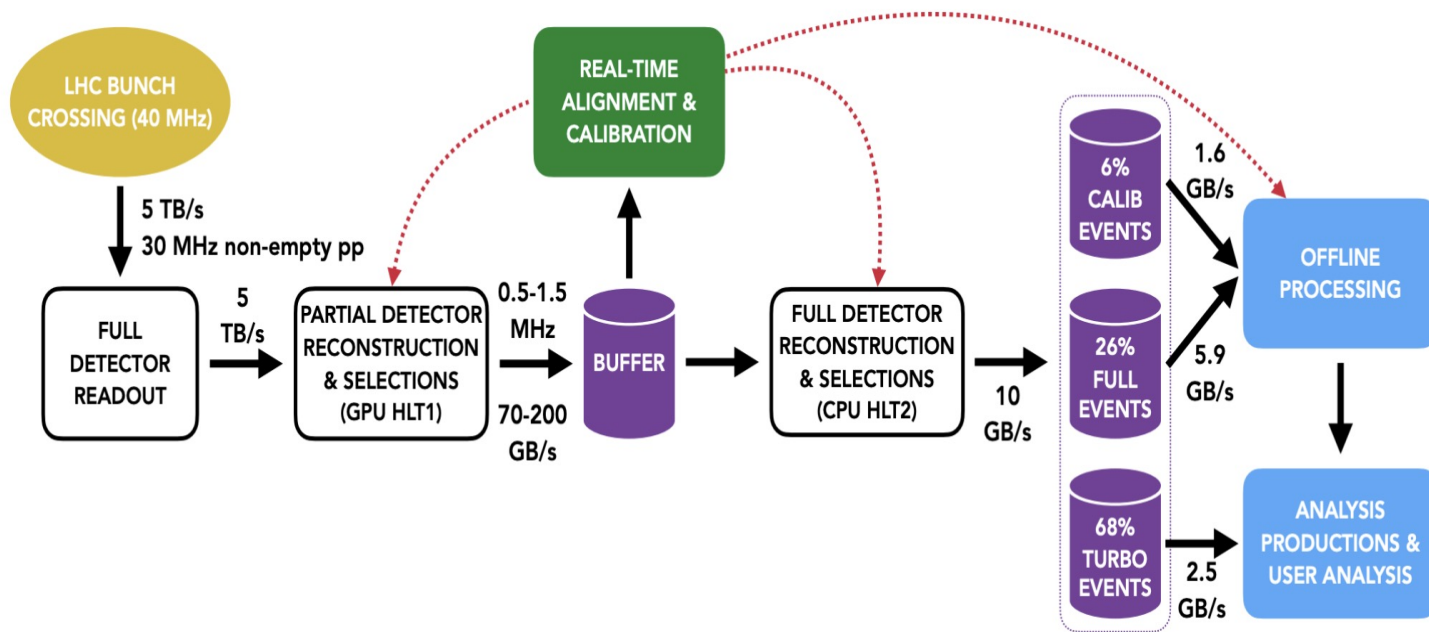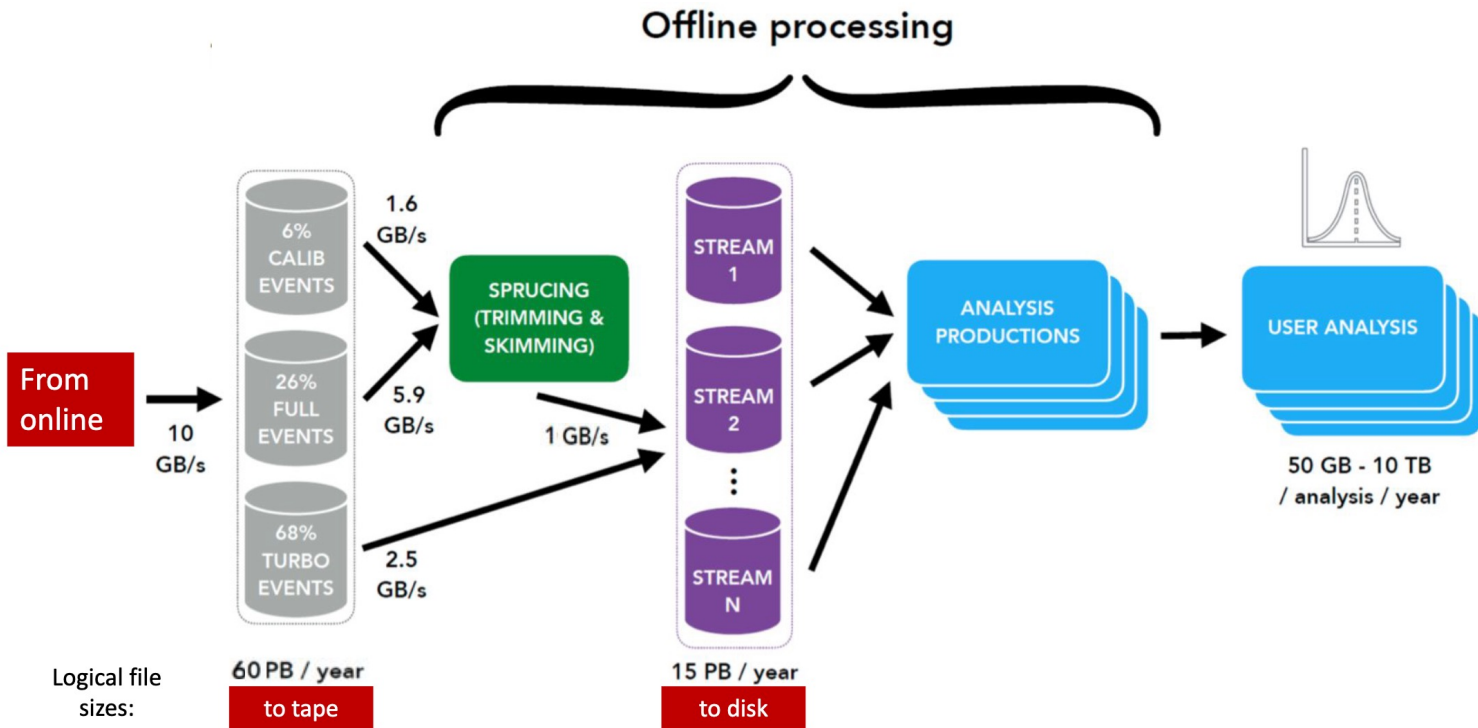# LHCb RUN3 activity

Andrei Tsaregorodtsev on behalf of the LHCb Computing Project,

Journées LCG-France

1st December, 2023, Lyon
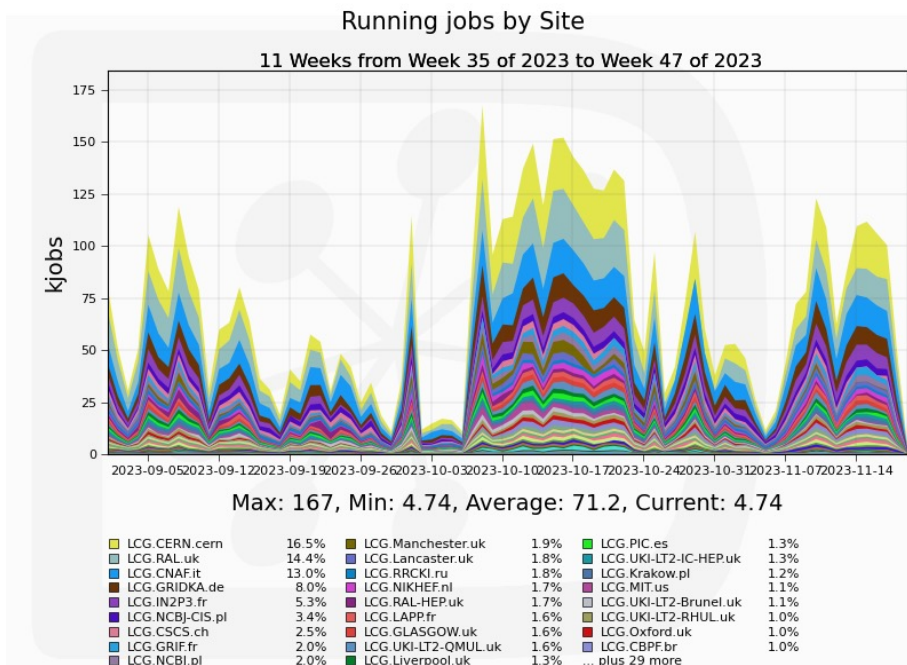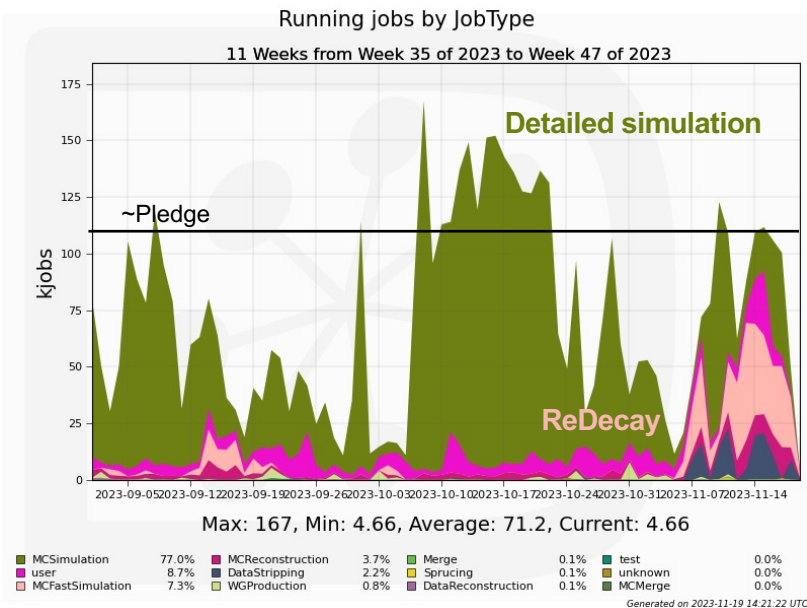
LHCb Run3 Computing model reminder: online

LHCb Run3 Computing model reminder: offline

Distributed computing operations

- Computing work: MC production (89%), physics analysis (9%), data reconstruction and selection (stripping/sprucing, 2%)
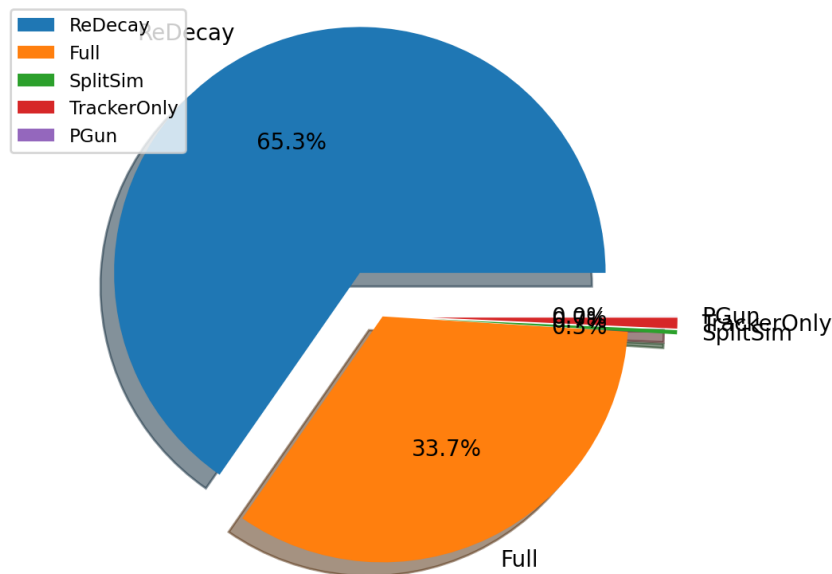- Usual mix of sites T0:T1:T2 ~ 40:40:20

Similar pattern in 2024-2025

Distributed computing operations

- Simulating about 100 million events per day in the last three months
- 1/3 of events produced with detailed simulation in the last 365 days
- long tail of Run1+Run2 simulation, confirming computing model assumption
- Small Run3 simulation samples produced for specific purposes (early measurements, HLT bandwidth division, detector and software performance studies, etc.)

All Events Last 365 Days by Simulation Type

Legend:
- ReDecay
- Full
- SplitSim
- TrackerOnly
- PGun

ReDecay 65.3%
Full 33.7%
SplitSim 0.5%
TrackerOnly 0.0%
PGun 0.0%

Evolution of Mean Number of Simulated Events per Day

- Mean 7 days
- Mean 30 days
- Mean 90 days

4.6E+08
1.7E+08
1.0E+08

2023 – turned out to be a commissioning year:
- Velo acceptance limited
- UT is in commissioning mode
- Underuse of storage resources
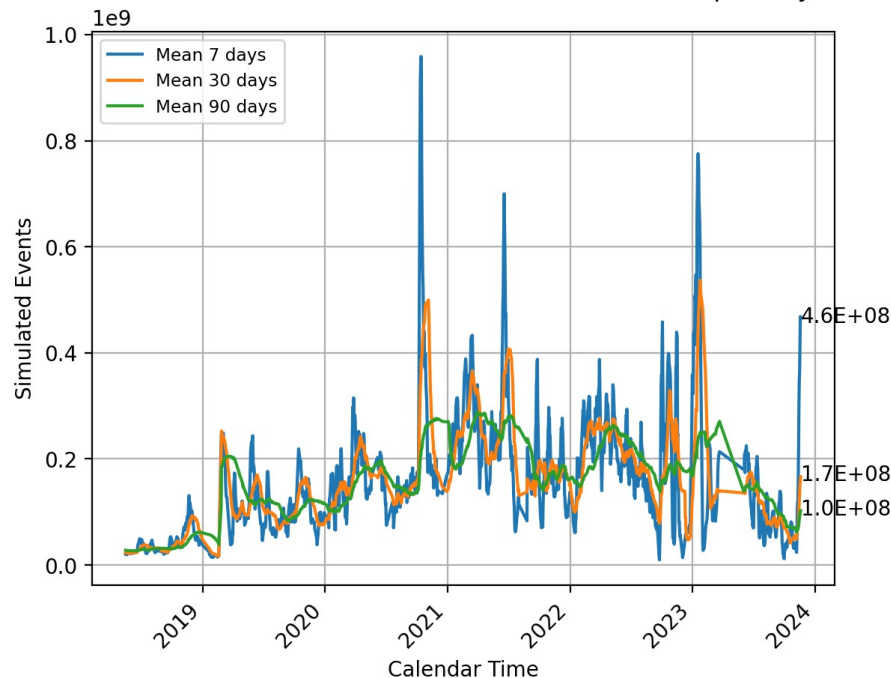
Lots of real data productions

- Offline re-run of HLT2 on 2022 proton collision data
  - Small but precious dataset
    - VELO closed to nominal position
  - Validation completed, production imminent
  - Sprucing will follow afterwards
- Sprucing of 2023 proton collision data completed
  - Commissioning and collision data
  - Before and after June technical stop
- Stripping of Run2 datasets
  - Key to LHCb physics output in the next couple of years
  - 2016 dataset running, 50% complete
  - 2017 and 2018 will follow
  - Staging from tape massive amounts of data
  - Stripped data need additional 2PB logical (4PB physical) disk space

Running jobs by Site
11 Weeks from Week 35 of 2023 to Week 47 of 2023

Stripping of 2016 data

Max: 20,198, Average: 1,567, Current: 324

LCG.CERN.cern	27.1%	LCG.GRIDKA.de	11.5%	LCG.NIKHEF.nl	2.9%
LCG.CNAF.it	22.8%	LCG.IN2P3.fr	11.0%	LCG.SARA.nl	1.6%
LCG.RAL.uk	18.3%	LCG.PIC.es	4.7%	LCG.NIPNE-07.ro	0.0%

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Running jobs by ProcessingType
11 Weeks from Week 35 of 2023 to Week 47 of 2023

Processing of 2023 pp data

Max: 910, Average: 72.8, Current: 9.64

Real Data/HLT201	71.5%	Real Data/Sprucing23	7.7%	Real Data/SprucingPass23r1	5.7%
Real Data/Sprucing23r1	8.7%	Real Data/SprucingPass23	6.4%		

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Heavy ion data

- Heavy ion collision data processing
  - Run HLT2 on the online farm at the pit
    - HLT farm will be not used for simulation during the shutdown
  - Run sprucing offline
  - Expected 4PB (2PB) logical file size on tape (disk)
    - Physical file size will be twice (two copies)

- **HI+fixed target** is representing about 10% of required resources
  - This is the assumption for both CPU and storage for 2024-2025 request
  - Otherwise goes through the same workflow as pp-collisions data
  - HI run is to be confirmed for 2024

New LHCb Tier1 sites

- The NCBJ (Warsaw) and IHEP (Beijing) Tier2 sites have progress towards becoming Tier1 sites for LHCb
  - requirements in terms of network, storage (most notably: tape), services, service level agreement
- NCBJ: network OK, computing hardware and configuration ready
  - Tape software has been upgraded in September, data challenge has been performed successfully
  - Final commissioning in December'23
- IHEP: computing HW and SW OK, network ~OK
  - 100Gps available in shared mode, functional tests OK, data challenge imminent
  - Dedicated 10Gps link to LHCOPN is in progress
  - Final commissioning 1H'24
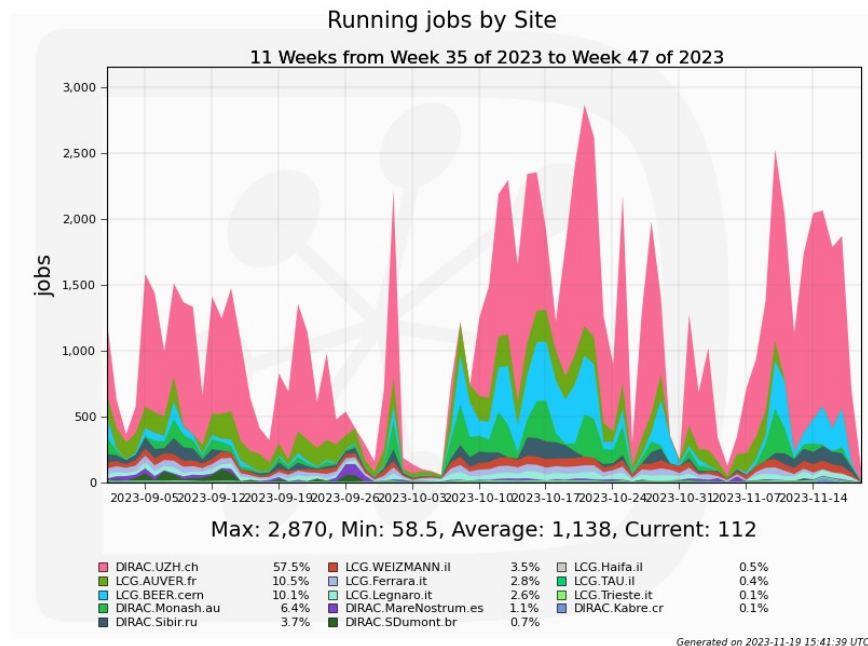- IHEP and NCBJ will add ~5% each to the LHCb resources

NATIONAL CENTRE FOR NUCLEAR RESEARCH
ŚWIERK
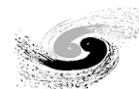
Institute of High Energy Physics
Chinese Academy of Sciences
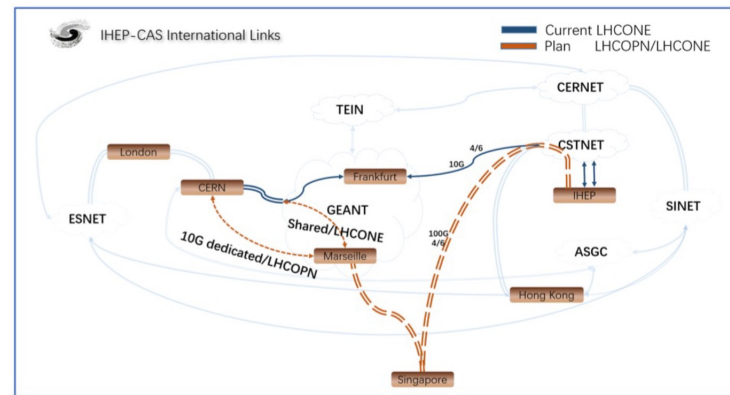
Opportunistic resources

- Fraction of jobs executed on totally opportunistic resources stable at a few percent level
- Zurich (CH), Beer (CERN), Monash (AU), Sibir (RU), Barcelona (ES)
- Barcelona Supercomputing Center (MareNostrum), SDumont.br and CSCS are production HPCs
  - CINECA – GPU access
  - small center in Costa Rica (Kabre) recently added
- WLCG sites not pledging to LHCb in France, Israel, Italy are also utilised opportunistically

Running jobs by Site
11 Weeks from Week 35 of 2023 to Week 47 of 2023

Max: 2,870, Min: 58.5, Average: 1,138, Current: 112

■ DIRAC.UZH.ch	57.5%	■ LCG.WEIZMANN.il	3.5%	■ LCG.Haifa.il	0.5%
■ LCG.AUVER.fr	10.5%	■ LCG.Ferrara.it	2.8%	■ LCG.TAU.il	0.4%
■ LCG.BEER.cern	10.1%	■ LCG.Legnaro.it	2.6%	■ LCG.Trieste.it	0.1%
■ DIRAC.Monash.au	6.4%	■ DIRAC.MareNostrum.es	1.1%	■ DIRAC.Kabre.cr	0.1%
■ DIRAC.Sibir.ru	3.7%	■ DIRAC.SDumont.br	0.7%		

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Jobs at the French sites

Running jobs by Site

30 Days from 2023-10-31 to 2023-11-30

Max: 17.0, Min: 0.22, Average: 9.15, Current: 2.05

| LCG.IN2P3.fr | 52.2% | LCG.LAPP.fr | 14.6% | LCG.LPC.fr | 5.5% |
| LCG.GRIF.fr | 18.8% | LCG.CPPM.fr | 8.5% | LCG.AUVER.fr | 0.5% |

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GPU usage in LHCb

LHCb (main messages) – J.Flix, Nov'23 GDB

- The Allen framework is used in Run3 to execute on the event building farm GPUs the first HLT stage (HLT1). Offline GPUs could be used to emulate the HLT1 in simulation through Allen

- A few LHCb analysts use GPUs, but they use resources on institute clusters which are outside WLCG. Actual usage is unknown. Fast simulations use machine-learning techniques currently implemented on CPUs, but they might be ported on GPUs in future. LHCb might be using opportunistically the GPUs on the online event builder farm when not in use for data taking

- No established plans on GPU resource demands or for future utilization at sites. Some discussion have started in the context of GPU usage for physics analysis, in the context of analysis facilities. November 2023 workshop to understand how to use GPUs/accelerators also in later processing stages, in the context of future Run4/Run5 LHCb Upgrades

- LHCb is totally dominated by simulation (using above 90% of compute resources). R&D towards porting (parts of) simulation on GPUs, provided they can be advantageous in terms of performance and required resource

Tokens usage in LHCb

- LHCb IAM instance is in place

- Accessing CPU resources with tokens
  - Most of the HTCondorCE sites are configured for token access
  - Tests with ARC6 sites were successful, ARC7 tests are ongoing

- Accessing storage resources
  - "Following the WLCG schedule" – not very aggressive
  - Unlikely to be used in the DC'24 in February

2024 pledges

- Snapshot from CRIC
- CPU OK
- Tape ~OK
- Disk -15%

Tier	Pledge Type	Year	LHCb Required	LHCb Pledged	LHCb Balance
0	Disk	2024	30600	30600	0 %
0	Tape	2024	117100	117100	0 %
0	CPU	2024	174000	174000	0 %
1	Tape	2024	133300	125155	-6 %
1	Disk	2024	61200	52986	-13 %
1	CPU	2024	572000	542293	-5 %
2	Disk	2024	11800	9381	-20 %
2	CPU	2024	319000	393541	23 %
Tier	Pledge Type	Year	LHCb Required	LHCb Pledged	LHCb Balance

Preliminary 2025 requests

Model assumptions for 2025	
L ($cm^{-2}s^{-1}$)	2×10^{33}
Pileup	6
Running time pp collisions (s)	6.3×10^6
Output bandwidth (GB/s)	10
Fraction of Turbo events	73%
Ratio Turbo/FULL event size	16.7%
Ratio full/fast/param. simulations	36:64:0
Data replicas on tape	2; 1 for derived data
Data replicas on disk	2 (Turbo); 3 (FULL, TurCal)
Simulation replicas (disk and tape)	1

stream	rate fraction	TAPE throughput (GB/s)	TAPE bandwidth fraction	DISK throughput (GB/s)	DISK bandwidth fraction
FULL	26%	5.9	59%	0.8	22%
Turbo	68%	2.5	25%	2.5	72%
Calibration	6%	1.6	16%	0.2	6%
Total	100%	10.0	100%	3.5	100%

Preliminary 2025 requests

CPU Work in WLCG year (kHepScore23.years)	2024 LHCb-PUB-2023-001	2025 prel. THIS DOCUMENT
First pass sprucing	70	82
End-of-year sprucing	70	82
Simulation	800	1336
Core and distributed computing infrastructure	10	10
User Analysis productions	214	319
Total Work (kHepScore23.years)	**1165**	**1829**
LHCb-TDR-018	**3470**	**3276**

Disk storage usage forecast (PB)		2024 LHCb-PUB-2023-001		2025 prel. This document	
Real data	Run1+Run2 pp data	10.2	78.7	10.2	134.4
	Run1+Run2 HI+SMOG				
	Run3: FULL	16.5		30.9	
	Run3: TURBO	36.3		68.1	
	Run3: TURCAL	4.5		8.4	
	Run3: Minimum bias	0.0		0.0	
	Run3: HI+SMOG2	11.2		16.8	
Simulated data	Run1+Run2 Sim	8.7	11.9	8.7	16.7
	Run3 simulated data	3.2		8.0	
Other	User data	3.0	13.0	3.6	15.6
	Buffers	10.0		12.0	
Total		**103.6**		**166.7**	
LHCb-TDR-018		**165.0**		**171.0**	

Tape storage usage forecast (PB)		2024 LHCb-PUB-2023-001		2025 prel. This document	
Run1 + Run2	RAW data (pp+HI+fix target)	36.9	79.4	36.9	80.4
	RDST data (pp+HI+fixtarget)	13.8		13.8	
	ARCHIVE	28.7		29.7	
Run3	pp data (FULL+TURBO+TURCAL)	144.0	171.0	270.0	317.1
	minimum bias / no-bias	0.6		0.6	
	Heavy Ion + fixed target	11.2		16.8	
	ARCHIVE (data+MC)	15.1		3.7	
Total			**250.4**		**397.5**
LHCb-TDR-018			**348.0**		**351**

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Preliminary 2025 requests

- 60% increase with respect to 2024 request
- Long tail of the R1+R2 simulation
- **HI+fixed target** is representing about 10% of required resources

LHCb		2024		2025 (prelim.)	
		Request	2024 req./2023 pledge	Request	2025 req. / 2024 CRSG
WLCG CPU	Tier-0	174	81%	283	162%
	Tier-1	572	96%	928	162%
	Tier-2	319	74%	518	162%
	HLT	50	100%	50	100%
	Sum	1115	89%	1779	160%
Others		50	100%	50	100%
Total		**1,165**	**93%**	**1,829**	**157%**
Disk	Tier-0	30.6	101%	49.2	161%
	Tier-1	61.2	112%	98.5	161%
	Tier-2	11.8	150%	19.0	161%
	Total	**103.6**	**111%**	**166.7**	**161%**
Tape	Tier-0	117.1	129%	189.3	162%
	Tier-1	133.3	99%	208.1	156%
	Total	**250.4**	**111%**	**397.5**	**159%**

Disk space at T1/T2 sites

- The division of the disk space request between T1 and T2-D sites is not strict
  - Prefer to concentrate disk storage on fewer sites to help data manager's operations
  - Countries without T1 are welcome to provide T2-D sites

- T2-D sites are mostly running user analysis jobs
  - Data stored can depend on analysis production procedures
  - Often results in a low occupancy of T2-D storage

Outlook for Run4

- 2024 requests ~ 2023 requests
- resource profile flattens in LS3 and returns to the "constant budget" line in Run4

C. Bozzi. LHCb
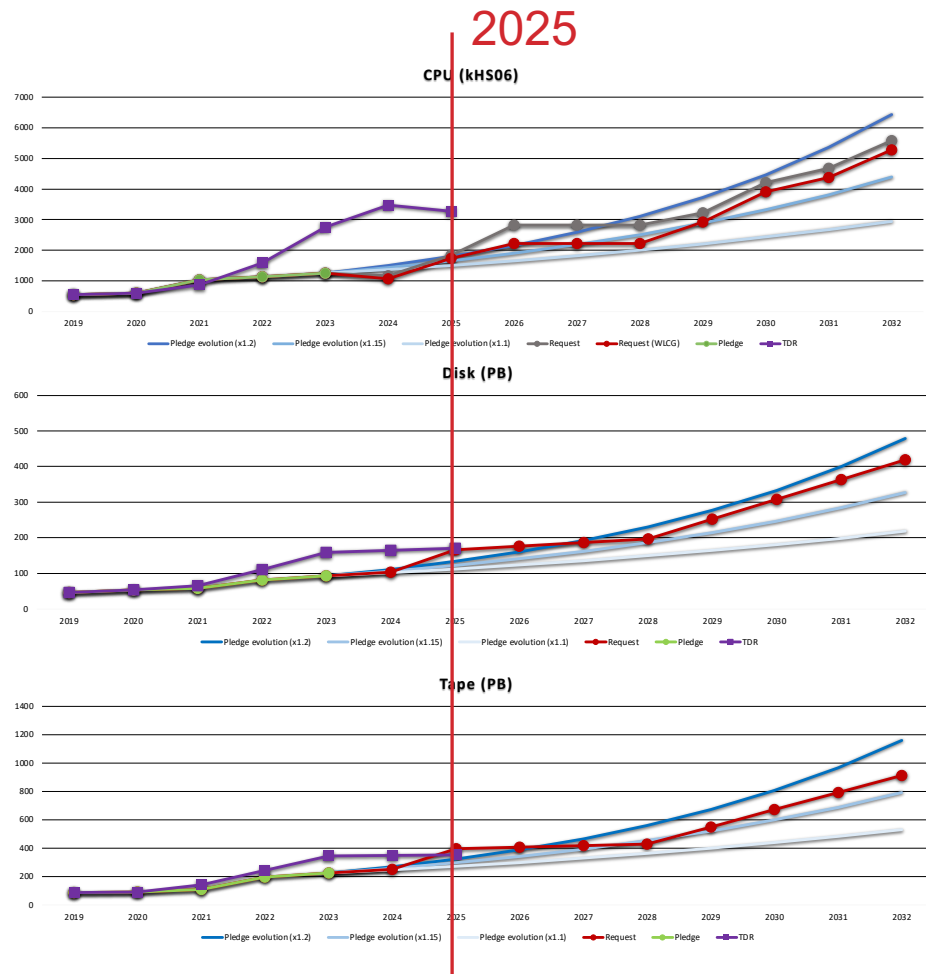
Conclusions

- Smooth operations: 90% MC + 10% data (re)processing and user analysis
- New T1 centers (NCBJ,IHEP) will be soon going into production contributing ~5% of resources each
- Stable use of opportunistic resources on few percent level (non-pledged, HPC)
- Tokens usage is following the WLCG schedule
- 2025 request is showing 60% increase
- Flattening request for LS3 will result in returning to the flat budget curve for Run4

Back-up slides

Storage usage

Overall, LHCb are using ~135PB, an increase of ~5PB over the last quarter

This is divided between Disk (~62PB) and Tape (~73PB). Note that the disk value is still ~18PB over the requested amount for 2023

Transfer rates peaked at 50 GB/s with an average between 5-10 GB/s

DISK Usage by Storage Element
12 Weeks from Week 26 of 2023 to Week 39 of 2023

Max: 67.7, Min: 62.9, Average: 65.4, Current: 62.9

CERN-DST-EOS	7.6%	IN2P3-DST	3.5%	CERN-BUFFER	2.1%
CERN_MC-DST-EOS	6.4%	CERN-DC-DAQ-EXPORT	3.2%	RRCKI-DST	2.0%
RAL-DST	6.0%	GRIDKA-RDST	2.9%	SARA-RDST	1.9%
CNAF-DST	5.1%	CNAF_MC-DST	2.7%	GRIDKA-BUFFER	1.8%
GRIDKA-DST	4.2%	IN2P3_MC-DST	2.7%	CNAF-BUFFER	1.5%
RAL-RDST	4.0%	IN2P3-RDST	2.7%	RRCKI-RAW	1.4%
RAL_MC-DST	4.0%	GRIDKA_MC-DST	2.7%	SARA_MC-DST	1.4%
CNAF-RDST	3.9%	RAL-BUFFER	2.5%	PIC-DST	1.2%
CERN-RDST	3.8%	SARA-DST	2.3%	... plus 79 more	

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TAPE Usage by Storage Element
12 Weeks from Week 26 of 2023 to Week 39 of 2023

Max: 73.9, Min: 66.4, Average: 69.9, Current: 73.9

CERN-RAW	33.5%	RAL-RAW	8.2%	IN2P3-RAW	3.6%	PIC-ARCHIVE	0.8%
CERN-ARCHIVE	10.8%	IN2P3-ARCHIVE	7.9%	SARA-RAW	2.5%	NCBJ-ARCHIVE	0.5%
RAL-ARCHIVE	9.5%	GRIDKA-RAW	5.3%	PIC-RAW	1.5%	SARA-ARCHIVE	0.4%
CNAF-ARCHIVE	8.6%	CNAF-RAW	5.3%	RRCKI-RAW	1.3%	GRIDKA-ARCHIVE	0.4%

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Throughput by Destination
12 Weeks from Week 26 of 2023 to Week 39 of 2023

Max: 52.1, Min: 1.45, Average: 12.6, Current: 5.00

RAL-BUFFER	13.1%	LCG.CNAF.it	3.3%	LCG.RRCKI.ru	1.2%
CERN-BUFFER	9.7%	SARA-BUFFER	3.2%	RAL-RAW	1.1%
CNAF-BUFFER	8.5%	PIC-BUFFER	3.1%	RAL_MC-DST	1.1%
GRIDKA-BUFFER	7.7%	RRCKI-BUFFER	2.8%	GRIDKA-RAW	0.8%
IN2P3-BUFFER	6.1%	LCG.GRIDKA.de	2.7%	CNAF_MC-DST	0.8%
CERN-DAQ-EXPORT	4.8%	LCG.IN2P3.fr	2.2%	GRIDKA_MC-DST	0.8%
LCG.RAL.uk	4.7%	CERN_MC-DST-EOS	1.5%	IN2P3_MC-DST	0.7%
CERN-RAW	3.7%	NCBJ-BUFFER	1.3%	CNAF-RAW	0.6%
LCG.CERN.cern	3.6%	LCG.PIC.es	1.2%	... plus 138 more	

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