LHCb computing introduction

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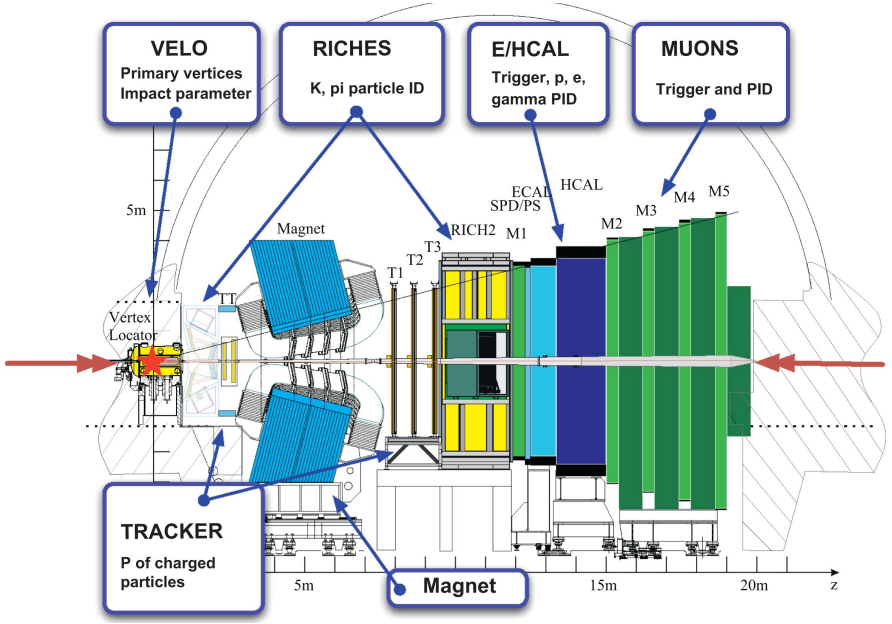
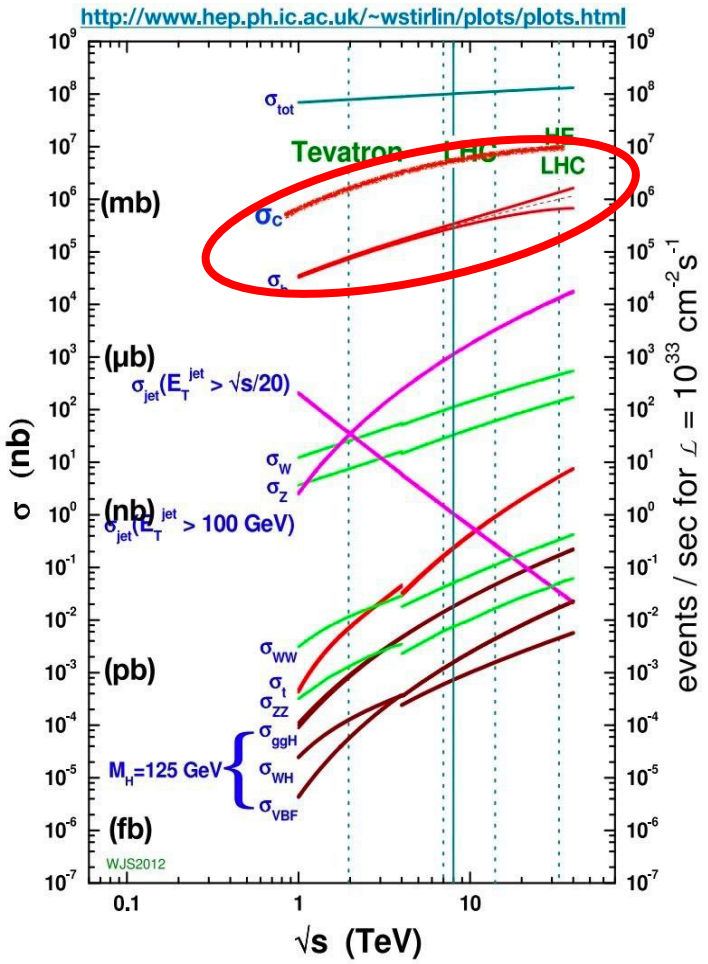
The LHCb experiment

- Dedicated for flavor physics studies, but also serve as a forward general-purpose detector
  - ➢ forward arm spectrometer with unique coverage in pseudorapidity ($2 < \eta < 5$)
  - ➢ catching 27% of b-quarks in 4% of solid angle
  - ➢ precision measurements in beauty and charm sectors
    - ✓ momentum resolution $\Delta p / p = 0.5\%$ at < 20 GeV/c to 1.0% at 200 GeV/c
    - ✓ IP resolution (15+29/pT[GeV]) μm for high-pT tracks
    - ✓ decay time resolution 45 fs for $B_s \to J/\psi\,\varphi$ and $B_s \to D_s\,\pi$
    - ✓ Particle ID with calorimeters, muon system and Cherenkov detectors (RICH)
  - ➢ Extended physics program to QCD, EW, direct searches
  - ➢ Participation in heavy ion runs
    - ✓ Unique operation mode as fixed-target experiment



Flavor physics objects and bandwidth

- Flavor physics objects
  - b / c – flavored hadrons
  - Large production cross-section
  - Large data sample need to be recorded
  - Large bandwidth
  - Currently bandwidth around 4 TB/s
  - Bandwidth with upgrade-II detector: around 25 TB/s
  - Largest bandwidth in HEP



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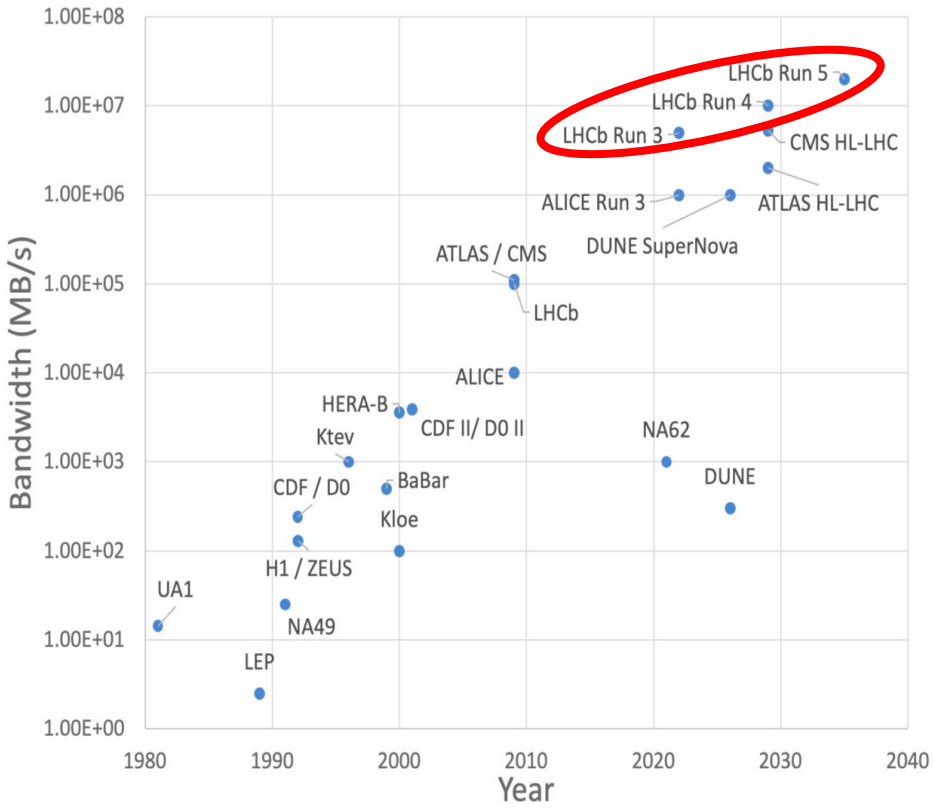
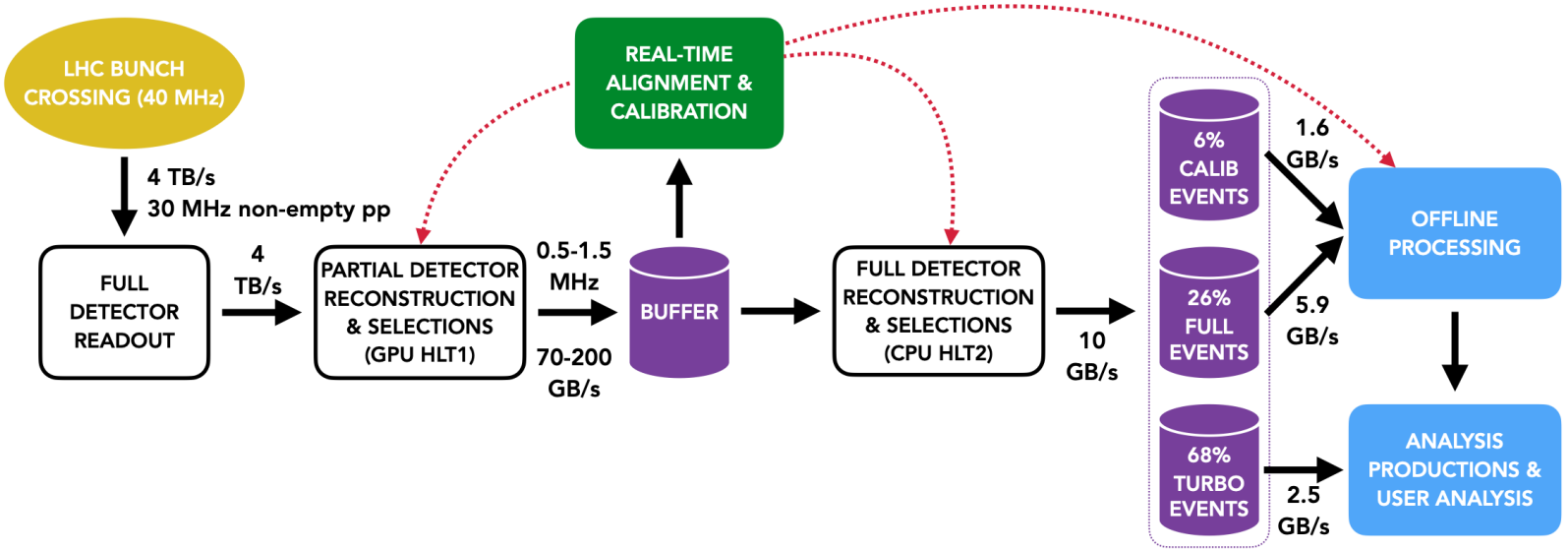


LHCb dataflow (Run-III)



- No hardware trigger, readout all collisions
- Two stages of software triggers, 10 GB/s to the storage
- LHCb needs more resources to support the future data processing
  - The requirement of computing resources is growing up by 15%/year, storage is 20% (Run3~Run5)

LHCb-China team's contribution to computing

- The Chinese team members make up 12% of the total number of the LHCb collaboration
  - ➢ Significant contributions to physics results, less contributions to computing before 2022
  - ➢ Contributions to computing is expected to be as significant as to physics
- LHCb also needs an Asian regional computing center to cover the jobs from Asia

The WLCG infrastructure is setup in tier levels. The Tiers used by LHCb are the Tier 0 at CERN, major Tier 1 sites in several countries and approximately ninety additional Tier 2 sites both in countries with Tier 1 centres and in other countries. The computing and storage resources, especially in North America and Asia, are expected to increase until the start of Run 3.

- **Average HPC utilized compute capacity in 2021**: 3x that of 2020 and **10x that of 2019**
  - CMS can consume HPC allocations very efficiently
  - Hard work on workload management, CMS software, and HTCondor submission infrastructure layer
- Integration of HPCs is transparent for operations. Two models:
  - HEPCloud: like a site, but a gateway to machines in the U.S.
  - Site extension: WLCG sites extended into HPCs. Used in Italy, Germany. Being commissioned in Spain.
- Significant integration expertise built up in the Dynamic Resource Provisioning team
- **Can the present HPC usage be expanded in other Asian or European countries, for example France or the U.K.?**

Build LHCb Tier-1 Site in China from 2022

- Existing LHCb Tier-1 site scales (2022)

Federation	Tier	VO	Country	Type	Pledge (HS06)	Pledge(cpu cores)
UK-T1-RAL	1	LHCb	United Kingdom	CPU	146665	7719
DE-KIT	1	LHCb	Germany	CPU	103874	5467
IT-INFN-CNAF	1	LHCb	Italy	CPU	103118	5427
FR-CCIN2P3	1	LHCb	France	CPU	74640	3928
NL-T1	1	LHCb	Netherlands	CPU	56714	2985
NRC-KI-T1	1	LHCb	Russian Federation	CPU	16400	863
ES-PIC	1	LHCb	Spain	CPU	13120	691

Federation	Tier	VO	Country	Type	Pledge (TBytes)
UK-T1-RAL	1	LHCb	United Kingdom	Disk	12474
IT-INFN-CNAF	1	LHCb	Italy	Disk	10461
DE-KIT	1	LHCb	Germany	Disk	8834
FR-CCIN2P3	1	LHCb	France	Disk	6771
NL-T1	1	LHCb	Netherlands	Disk	4823
NRC-KI-T1	1	LHCb	Russian Federation	Disk	2300
ES-PIC	1	LHCb	Spain	Disk	2120

Federation	Tier	VO	Country	Type	Pledge (TBytes)
UK-T1-RAL	1	LHCb	United Kingdom	Tape	32776
DE-KIT	1	LHCb	Germany	Tape	23213
IT-INFN-CNAF	1	LHCb	Italy	Tape	23044
FR-CCIN2P3	1	LHCb	France	Tape	18070
NL-T1	1	LHCb	Netherlands	Tape	10674
ES-PIC	1	LHCb	Spain	Tape	5560
NRC-KI-T1	1	LHCb	Russian Federation	Tape	3000

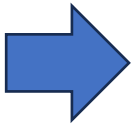
Decided to build a middle-scale Tier-1 site

- The starting budgets (￥6M) mainly from NHEPSDC (国家高能物理科学数据中心，hosted by IHEP-CC) and PKU (基础科学中心项目)
  - ➢ also budget supports from other LHCb institutes

Upgrade LHCb Tier-2 site to a Tier-1 site

- Computing resources (planed for Tier-1 site):

The previous Tier-2 site	The Tier-1 site at beginning
• Computing: 1680 CPU cores • Disk Storage: 375 TB	• Computing: 3280 CPU cores • Disk Storage: 3PB • Tape Storage: 3PB



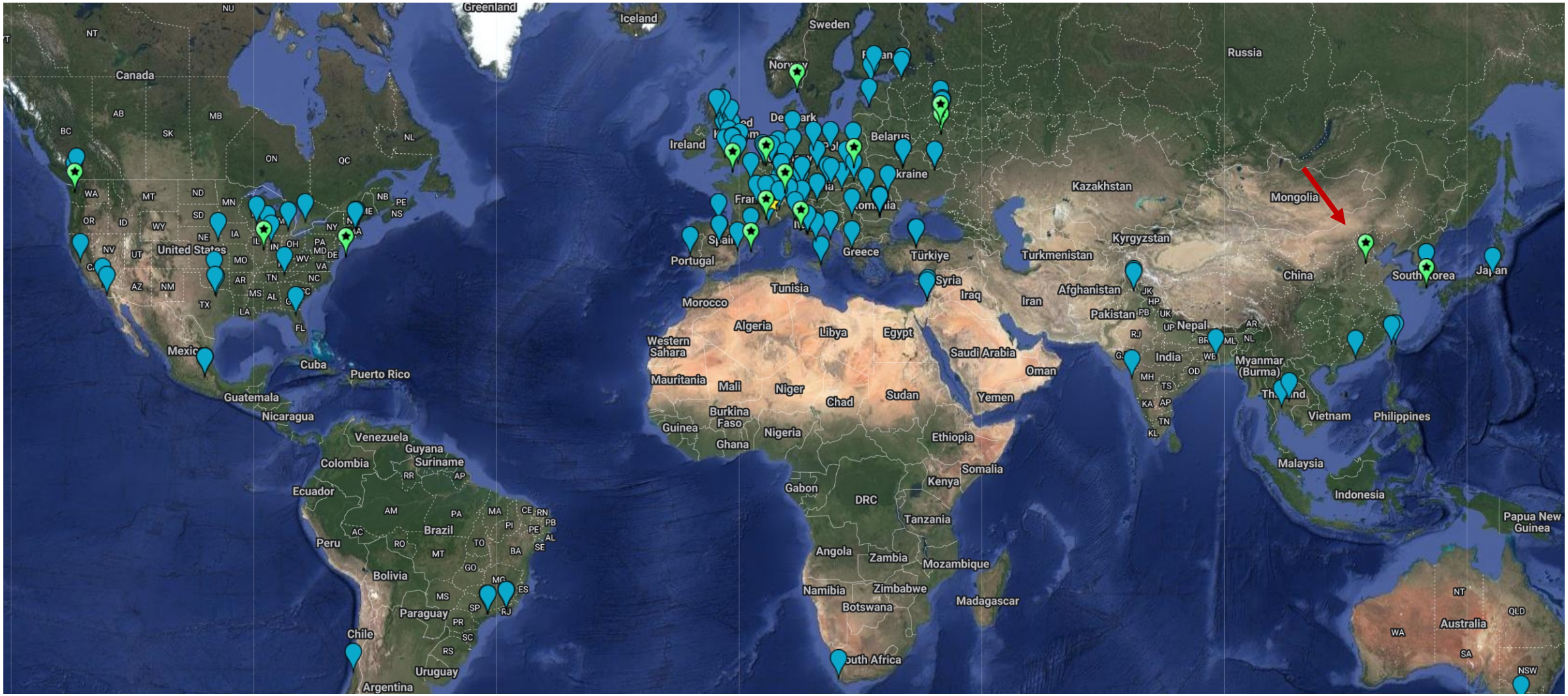
- Other resources are re-used from the IHEP-CC
  - Machine room infrastructure: electric power, cooling system,…
- The international network (new 100G) is build by CSTNET and IHEP-CC in cooperation

The Tier-1 Site Construction timeline

- In Sep. 2022, formulate the construction plan and estimated funding
- In Oct. 2022, LHCb Chinese Group decide to build a Tier-1 site
- In Dec. 2022, WLCG officially confirmed the establishment of the LHCb Tier1 Beijing site
- In Dec. 2022, begin procurement of equipment.
- In May. 2023, all equipment procurement was ready.
- In Jun. 2023, finish the site service setup and deployment
- In Oct. 2023, establish of the LHCOPN network link
- In Nov. 2023, complete basic functional test
- In Jun. 2024, complete the data challenge test
- In Jun. 2024, The “BEIJING-T1” site passed the WLCG OB review and officially joining the WLCG

- LHCb spokespersons, coordinators and WLCG coordinator visited the Tier-1 site and cared about the progress during the construction

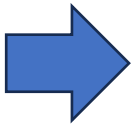
BEIJING-T1 site is in operation now



Tier-1 site scaling up

- LHCb management asks that the computing contribution should be compatible with the fraction of authors

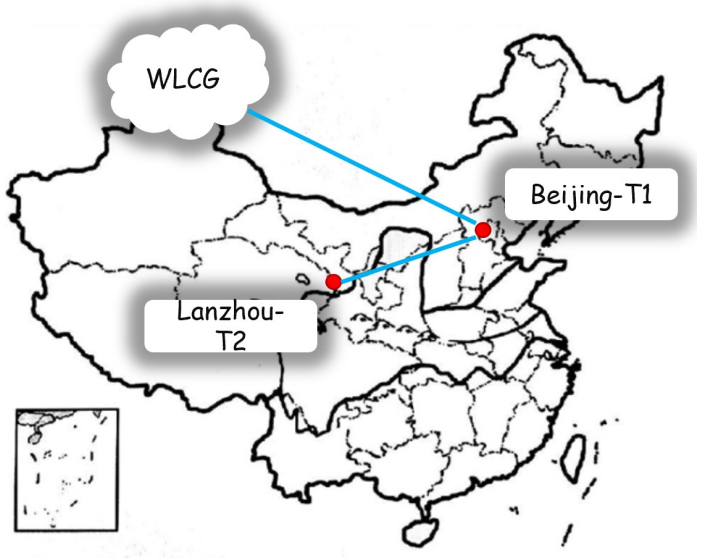
LHCb demands	Beginning of BEIJING-T1	planed this year
• Computing: ~5500 CPU cores • Disk Storage: 10.8 PB • Tape Storage: 23 PB	• Computing: 3280 CPU cores • Disk Storage: 3.2 PB • Tape Storage: 3 PB	• Computing: 3280 CPU cores • Disk Storage: 13 PB • Tape Storage: 10 PB



- LHCb is looking for more storage due to the storage problem of Italian site
- We still have gaps on the computing and tape storage and will discuss

New large LZU Tier-2 Site

- The largest Tier-2 site in LHCb (except CERN)
- The LZU site is based at Lanzhou University
  - ➢3520 CPU cores, ~77,000 HS23
  - ➢3.4PB Disk Storage
  - ➢Dedicated 2Gbps link between IHEP and LZU.
- Construction is ended
  - ➢Started running the LHCb jobs
- Jointly maintained by IHEP-CC and LZU
  - ➢Hardware maintenance: Lanzhou Univ.
  - ➢Software deployment and maintenance: IHEP-CC



LHCb visited LZU site

Computing Contribution from LHCb institutes

- All member institutes are contributing to computing

采购时间	经费来源	设备类型	设备数量	资源数量	设备名称	设备用途分类	设备详细用途
2022年9月	北大组	1U服务器	1台		publicfsmds	集群存储服务器	Tier3存储元数据服务器
2022年3月	国科大组	磁盘	5块	单块8TB		磁盘	存储阵列磁盘备件
2022年1月	国科大组	高密计算节点	8台	512 cores	lhcb003-010	HTC集群计算节点	Tier3计算节点
2021年8月	北大组	1U服务器	1台		condorce02	网格管理服务器	网格CE服务器
2021年8月	北大组	2U高密服务器	12台	672 cores	lwnlhcb039-050	网格计算节点	Tier2计算节点
2019年5月	国科大组	1U服务器	2台		gridnfs;gridvm005	网格管理服务器	网格中间件服务器
2018年11月	国科大组	1U服务器	2台		ccsrm,pupput-phy	集群存储服务器	网格SE服务器;监控服务器
2018年11月	华南师大组	10U刀片服务器	28台	1008 cores	lwn011-038	网格计算节点	Tier2计算节点
2018年11月	华南师大组	10U刀片服务器	2台	72 cores	lhcb001-002	HTC集群计算节点	Tier3计算节点
2018年11月	国科大组	1U服务器	1台		dpmlhcb01	网格存储服务器	网格存储服务器
2018年11月	国科大组	4U阵列	1台	480TB (裸)	dpmlhcb01-1	集群存储阵列	Tier2存储
2018年11月	国科大组	1U服务器	2台		lhcbfs01-02	集群存储服务器	Tier3存储服务器
2018年11月	国科大组	4U阵列	2台	480TB (裸)	lhcbfs01-1;lhcbfs02-1	集群存储阵列	Tier3存储/publicfs

- Maintenance fee per year: ~18% of hardware budget
- Most of the new project applications will consider computing budget
- The LHCb collaboration is increasingly valuing contributions in the area of computing

Thanks