Running Local Cluster Jobs at Remote Sites

Jingyan Shi

shijy@ihep.ac.cn

On Behalf of Computing Center, Institute of High Energy Physiscs

Outline

1 Introduction of IHEP-CC

2 Design of ”Running cluster job at remote site”

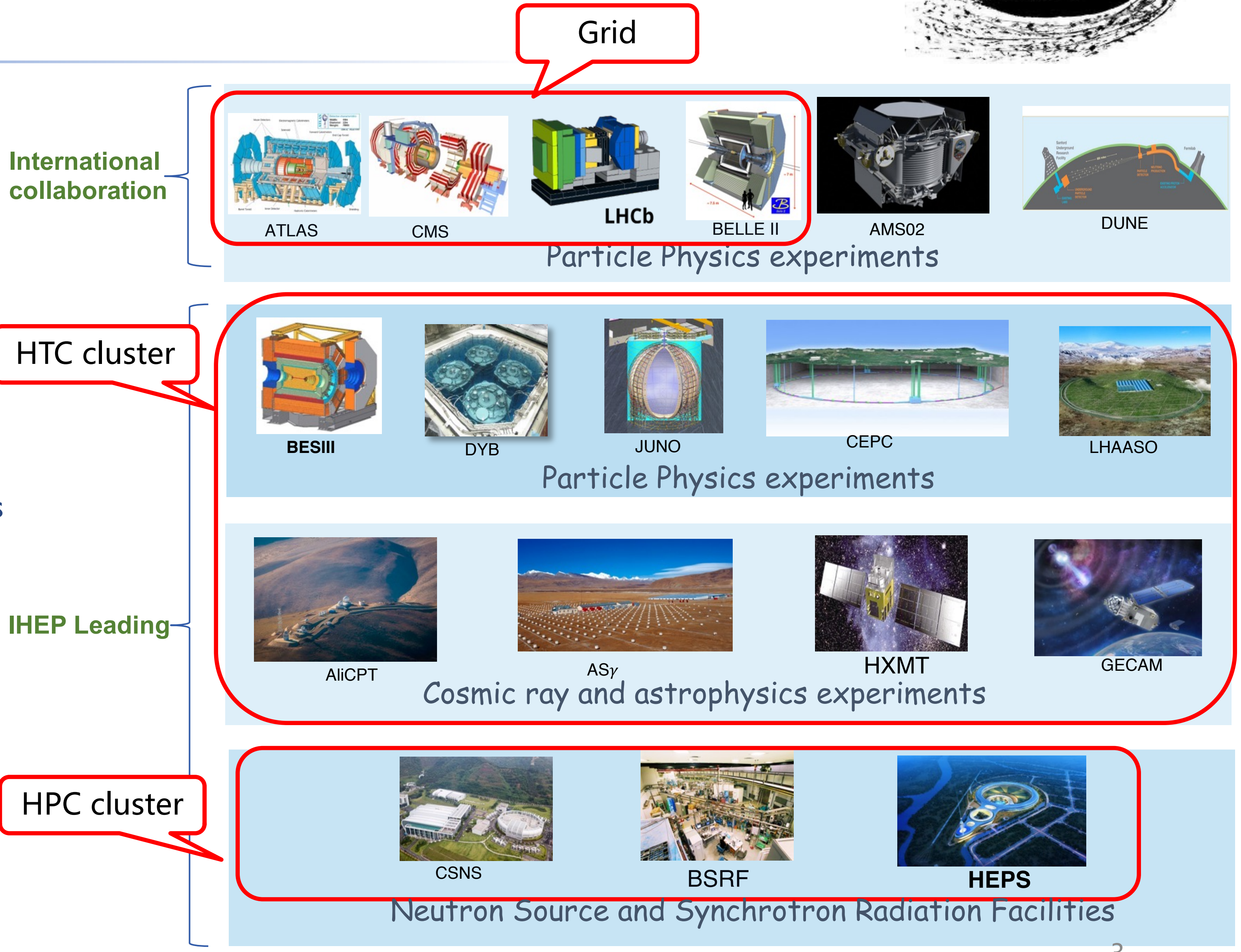
3 Current Progress

4 Next Plan

5 Summary

Brief Introduction to IHEP

- The largest fundamental research center in China with research fields:
  - Experimental Particle Physics
  - Theoretical Particle Physics
  - Astrophysics and cosmic-rays
  - Accelerator Technology and applications
  - Synchrotron radiation and applications
  - Nuclear analysis technique
  - Computing and Network application



Grid

International collaboration

ATLAS CMS LHCb BELLE II AMS02 DUNE

Particle Physics experiments

HTC cluster

BESIII DYB JUNO CEPC LHAASO

Particle Physics experiments

IHEP Leading

AliCPT ASγ HXMT GECAM

Cosmic ray and astrophysics experiments

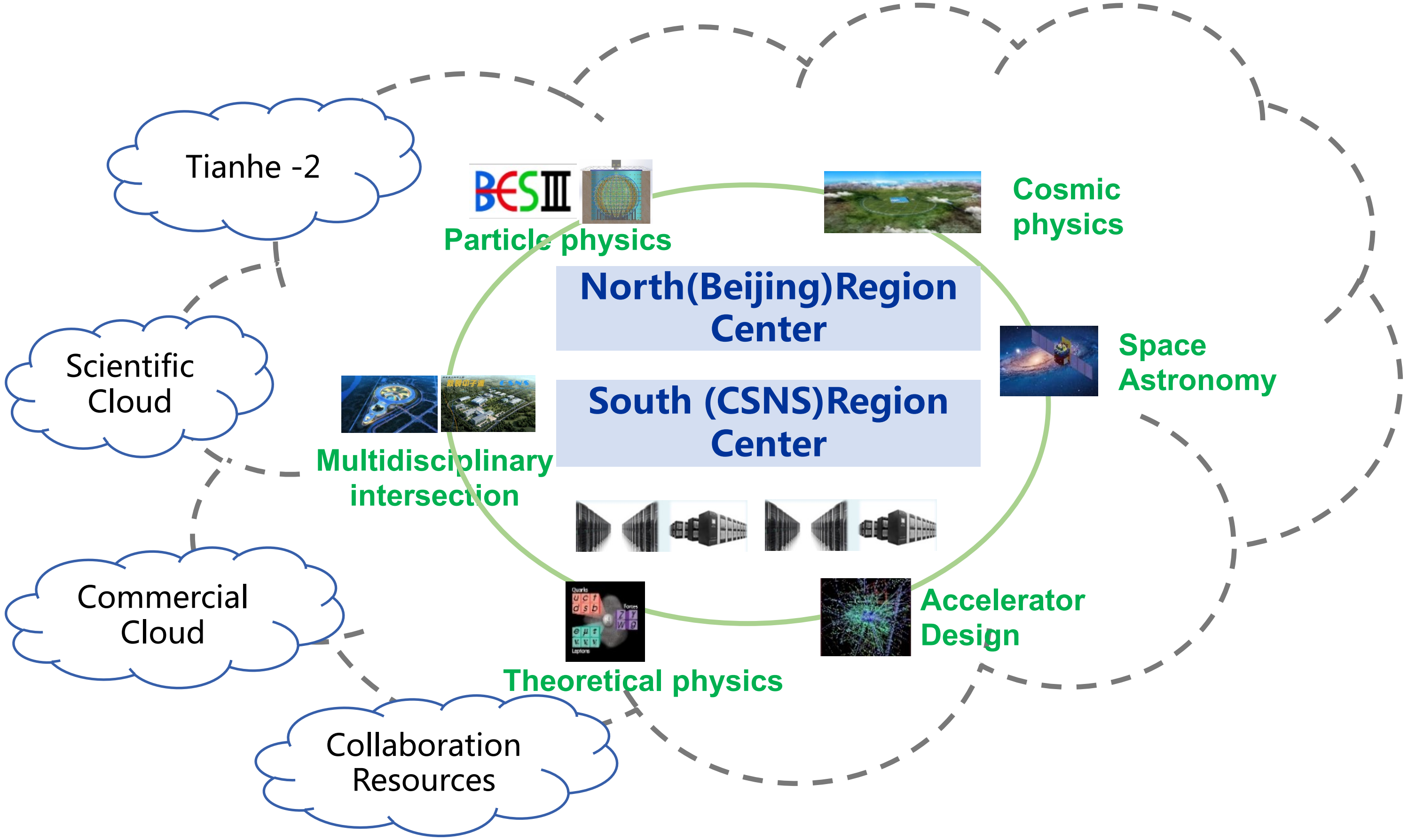
HPC cluster

CSNS BSRF HEPS

Neutron Source and Synchrotron Radiation Facilities

Brief Introduction to IHEP-CC

- Provide large-scale scientific computing environments for the HEP experiments
  - facilities
  - computing
  - storage
  - network
- Research on computing technologies to benefit high energy physics research
- 2 Region centers
  - North Region Center in Beijing (~45k cpu cores , ~80PB storage)
    - High Throughput Computing
    - High Performance Computing
    - Lustre file system
    - EOS file system
    - Tape Library
    - Tier 2 grid site of WLCG: WLCG grid middle ware deployed for the international collaboration
  - South Region Center in Dongguan
    - High Performance Computing
    - OceanStor9000 support by domestic vendor
    - Cloud Computing



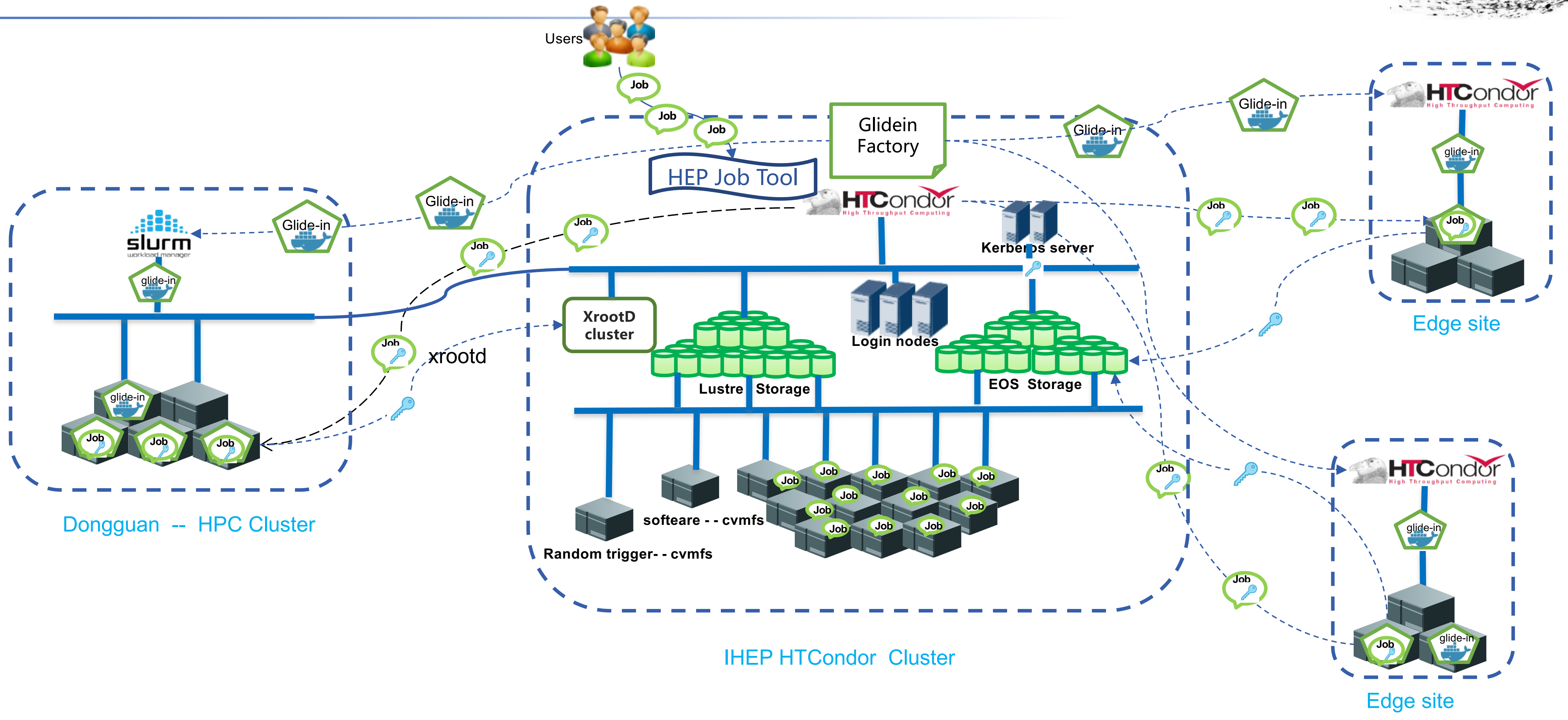
Motivation

- IHEP-CC would like to be the central site for domestic HEP Exp. computing
  - HTCondor cluster of IHEP-CC is the main place of offline data process
  - A “HEP Job Tool” based on HTCondor API developed for user to simplify user job management
    - Examples: hep_sub job.sh # no submit file needed ;
      hep_q jobid
    - Our user has become accustomed to the "cluster way" rather than the "grid way".
    - CPU resources remain highly utilized, resulting in significant job queuing time
  - Jobs running at local HTC directly access data files stored on the public file system
    - Lustre file system
    - EOS file system
- Remote sites
  - Dongguan offers 8k CPU cores and 10k arm CPU cores
    - 20Gbps dedicated link between Dongguan and IHEP → big data center
    - No storage space provided to IHEP
  - Edge site: collaboration member sites → small scale
    - Limited network connection without stable storage
  - Some super computing center is the potential resource provider
  - No extra manpower to maintain grid site at remote site
- Try to expand IHEP local HTCondor cluster to the remote site
  - Keep “the IHEP HTCondor cluster” way for the user

Issues to be Resolved

- Remote resources could be added to IHEP HTC cluster elastically and transparently
  - Drawing upon the "glidein" concept of grid, add remote resources to the IHEP LOCAL CLUSTER
- Scheduled the suitable jobs to the suitable remote worker node
  - Job and site classification
    - Find jobs with less IO and more cpu load
    - Tag site with size, stability and network link
  - Advanced scheduling algorithm
    - Send the necessary "glidein job" to the remote sitse from one "factory" based on the status of IHEP HTCondor cluster
- User authentication from remote ends
  - IHEP cluster authentication is based on kerberos
  - Kerberos token is the key to authenticate user from the remote site
- Access IHEP data file from remote ends
  - Transfer necessary files to/from the worker node's local disk via Xrootd protocol

Design


Users
Job
Job
Job
Glidein Factory
HEP Job Tool
HTCondor High Throughput Computing
Glide-in
Glide-in
Glide-in
Glide-in
slurm workload manager
glide-in
glide-in
Job
Job
Job
Job
Job
Job
xrootd
XrootD cluster
Lustre Storage
Login nodes
Kerberos server
EOS Storage
softeare - - cvmfs
Random trigger- - cvmfs
Job
Job
Dongguan -- HPC Cluster
IHEP HTCondor Cluster
HTCondor High Throughput Computing
glide-in
Job
Job
Job
Edge site
HTCondor High Throughput Computing
glide-in
Job
glide-in
Job
Job
Edge site

Site and Job Classification

- Site's characters
  - Scale: Big / small
  - Status: Stable / unstable
  - Network bandwidth： good / bad
- Cooperated with Exp. to classify and evaluate the job based on I/O and CPU load
- HEP Job Tool analysis the job and classify it as the attribute of the job
- Scheduler schedule the suitable jobs to run at the suitable remote worker node

Site Classification

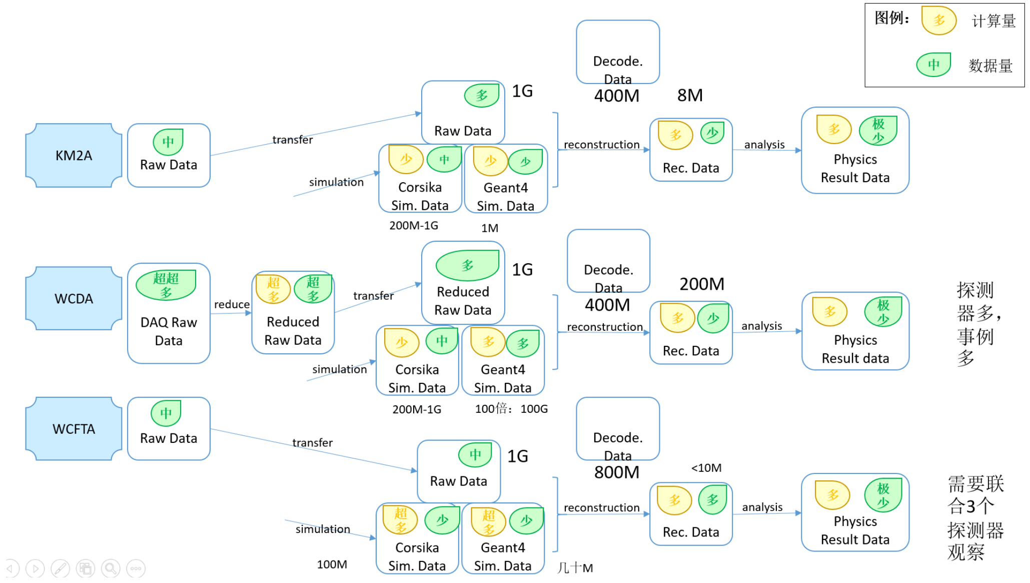
- Region site – North/South region center
  - Long term and stable computing, storage resource provided
  - Good network connection
- Edge site – collaboration member
  - No pledge storage
  - Limited network bandwidth
- Temporary site – commercial resource
  - Short term resources for the peak usage

Scheduler

Tag and Match

Job Classification

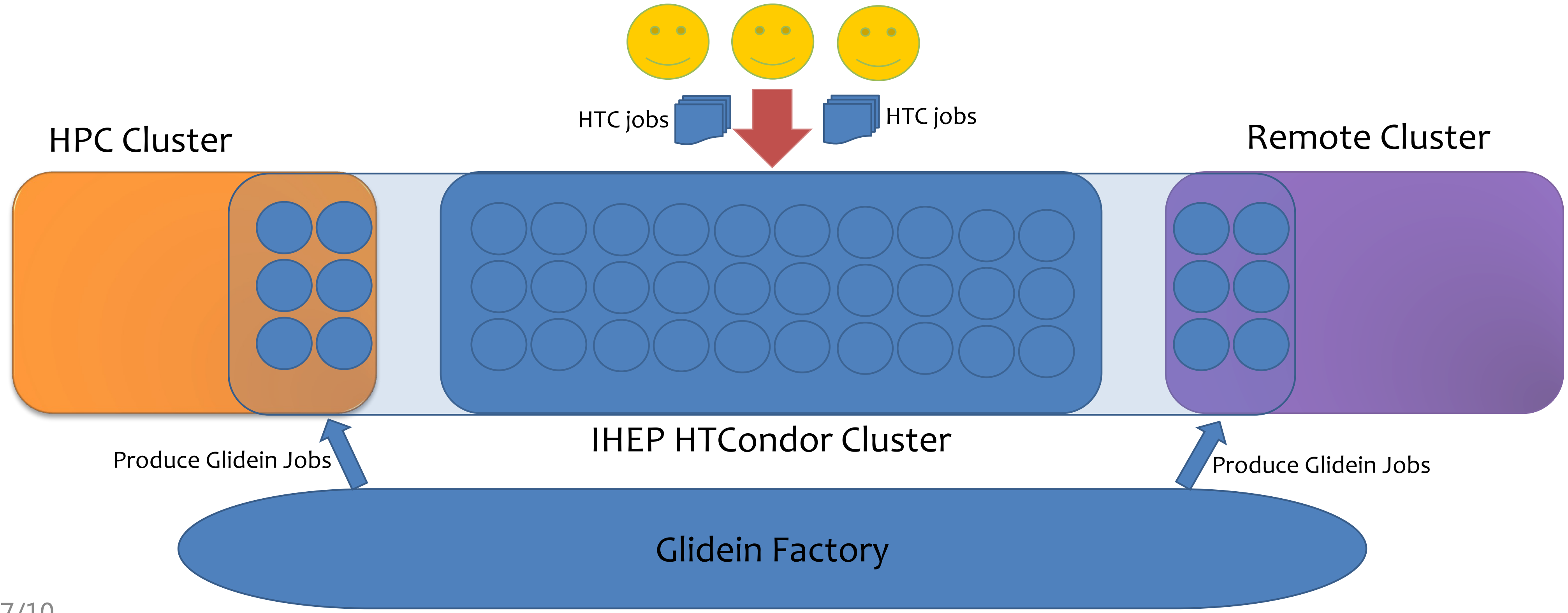
- Different Exp. Job has different characters
  - The percentages of simulation, reconstruction are different
  - IO requirement are different
  - Temporary storage requirement



LHAASO job classification i

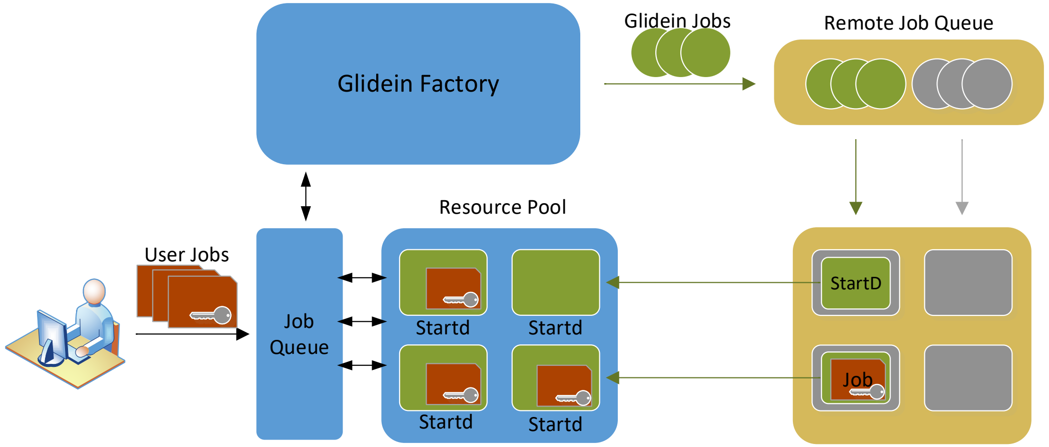
Cluster expansion -- glidein

- One Glidein factory produces glidein job and submit it to the the remote cluster
  - Running "startd" of IHEP HTCondor cluster
  - Make the user keep the original way of IHEP HTCondor Cluster



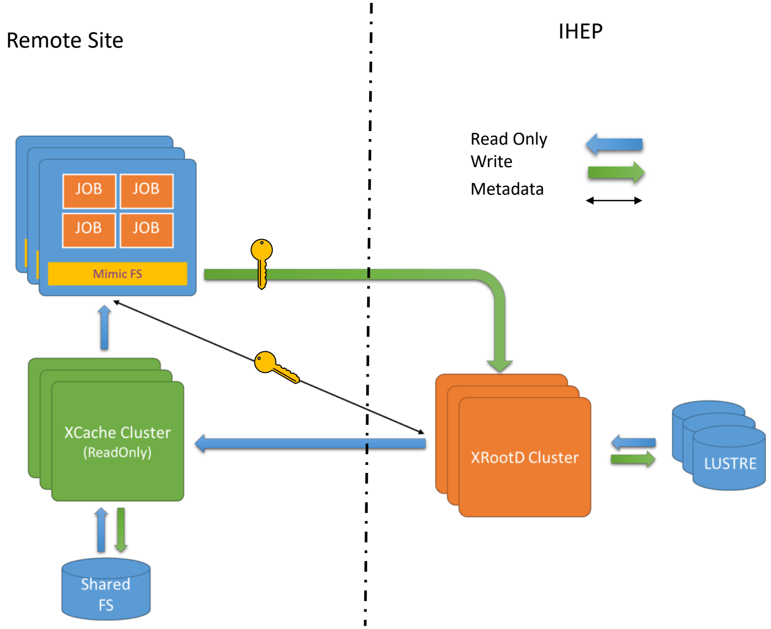
Token based Authethication

- HTCondor Service auth.
  - CLAIMTOBE → IDTokens
- User auth. from remote end
  - User authentication at IHEP is performed via Kerberos.
  - Tried the way of Kerberos token auth. using HTCondor
    - Unsupported: user namespace inconsistency between the submission side and the execution side
  - Developed an automatic process of kerberos token
    - Token transmission, token lifetime prolong, token destroy
    - Token ticket is initialized and valid inside job wrapper



Data File Access from Remote End

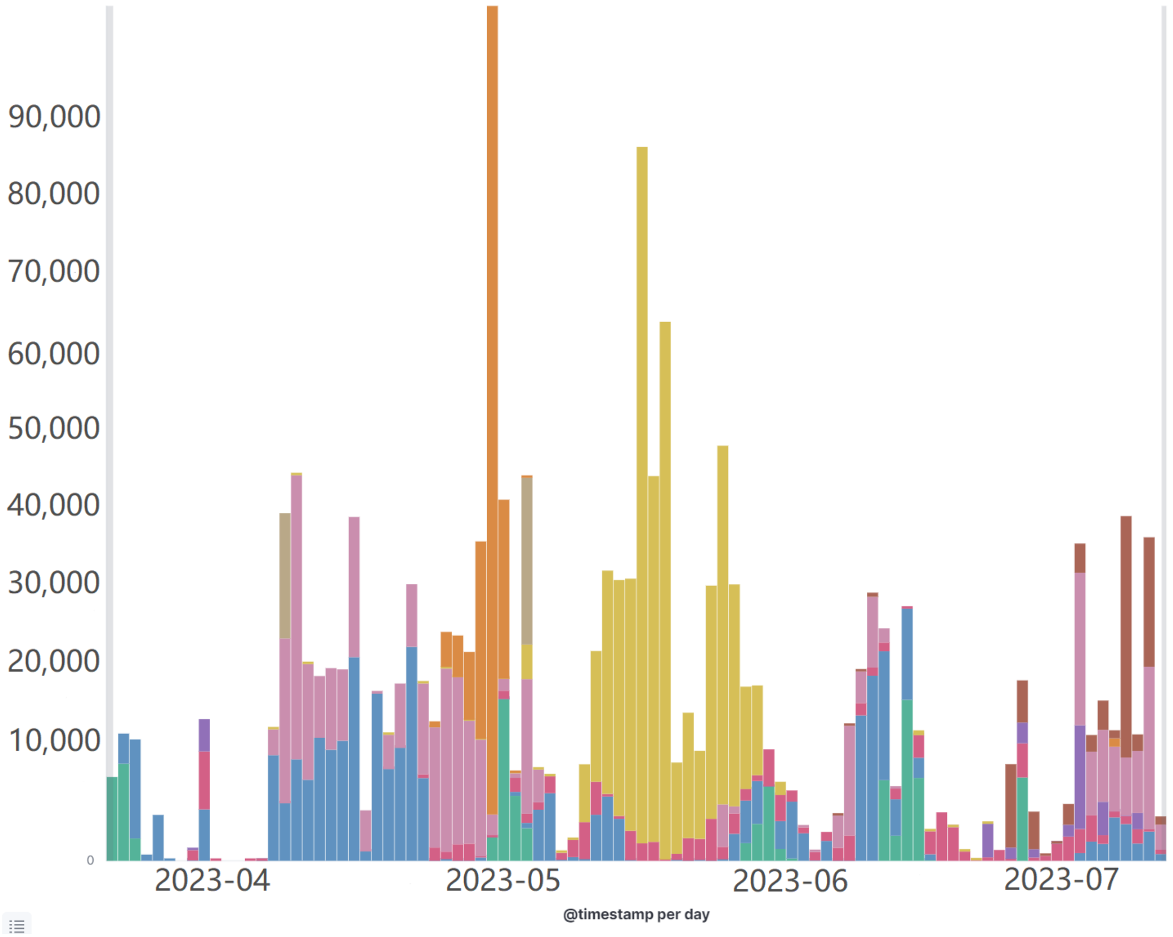
- Necessary files are found and transferred
  - Doe at remote worker node
  - File access need to be authenticated by token
  - File transferred to the local worker node disk via Xrootd protocol
    - Add XRootd cluster in front of lustre file sytem
    - EOS support XRootd naturally
- No public storage needed at remote site



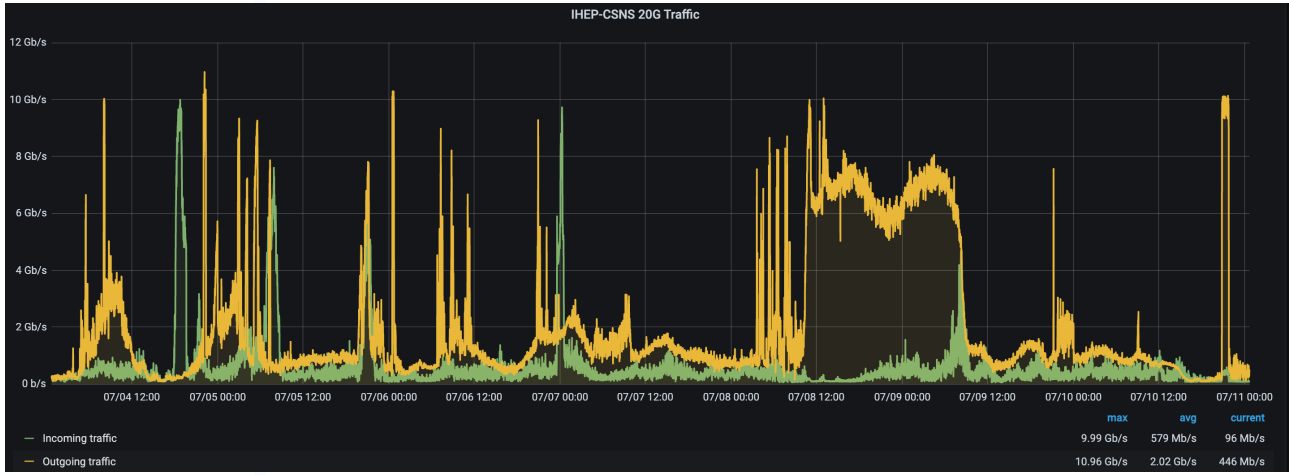
Current Progress

- Focus on the expansion to 8k intel CPU cores and 10k arm cpu cores at Dongguan
  - HEP exp. job classification has been done
  - Automatic kerberos token process has been developed and deployed
  - File transfer optimization via Xrootd has been done
  - No glidein factory till now but static glidein job running at Slurm cluster at Dongguan
- Some of the two HEP exp. Jobs are scheduled to Dongguan from IHEP HTCondor cluster
  - BES: Simulation and reconstruction jobs are **transparently** scheduled to run at Dongguan
    - Replace the pat at fixed job option template with the workernode local disk file path
    - Completely transparent to users → user does not care where his job runs
  - LHAASO: Corsika and simulation jobs are scheduled to run at Dongguan
    - User submit the job with –rmt
    - Could be run on both Intel and Arm machine at Dongguan
- Small sites test has been done

Running Status since 2023-04



****BES and LHAASO jobs has been run at Dongguan last 3 month



Traffic of IHEP-Dongguan network link

Next Plan

- Glidein factory with scheduling algorithm
- More exp. Jobs and more sites would be added
- Performance optimization
    - Compress the size of the files to be transmitted
        - User’s code and lib would be transferred once in one Cluster job
    - Xrootd performance evaluation and optimization
    - Big input file issues
        - Cvmfs or XCache ?

Summary

- Expand IHEP HTCondor cluster rather than grid to the remote site
  - Run IHEP HTCondor cluster as the central site and expand it
  - Two HEP exp. jobs have scheduled to run at Dongguan site from IHEP HTCondor cluster
- Still a lot of works need to be done
- Thank the HTCondor team for their assistance, and a special thanks to Greg for providing us with a wealth of technical support and guidance

Questions and Comments?

Backup – Arm Evaluation

- Evaluation
  - LHAASO Corsika job
  - ARM : Kunpeng 920@2.6 GHz, 48*2 cpu cores
  - X86 : Intel 5218@2.3 GHz, 16*2 cpu cores
- Single core

cpu	job	walltime(m)	idle power consumption(w)	Operating power consumption (w)
ARM	1	109	300	306
X86	1	90	180	240

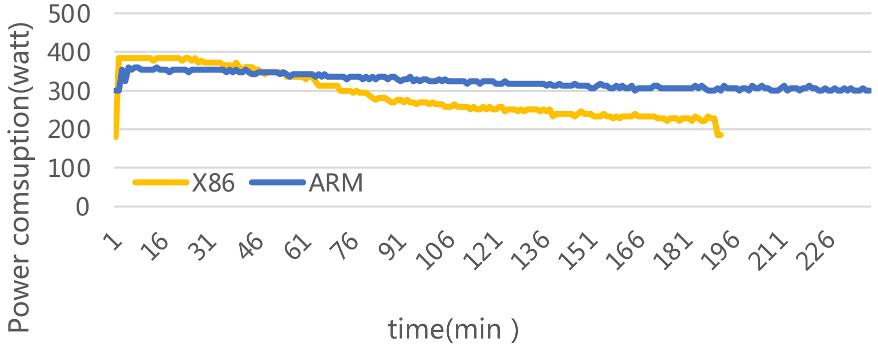
- Full cores

cpu	job	walltime	Average walltime of a single job.	Power consumption(w.h)
ARM	96	4h6m	103.75m	1355.51
X86	32	3h20m	83.09m	967.36

Kunpeng 920

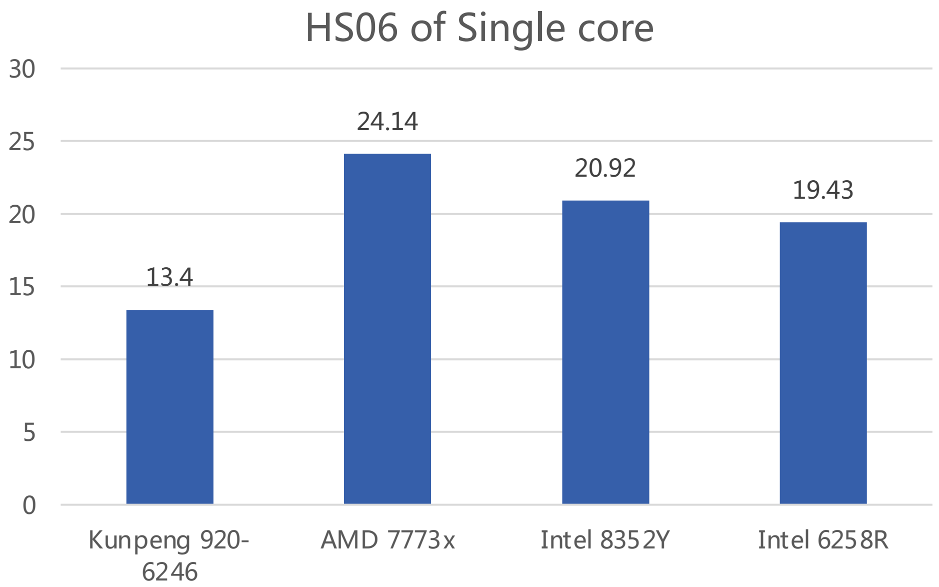
Intel 5218

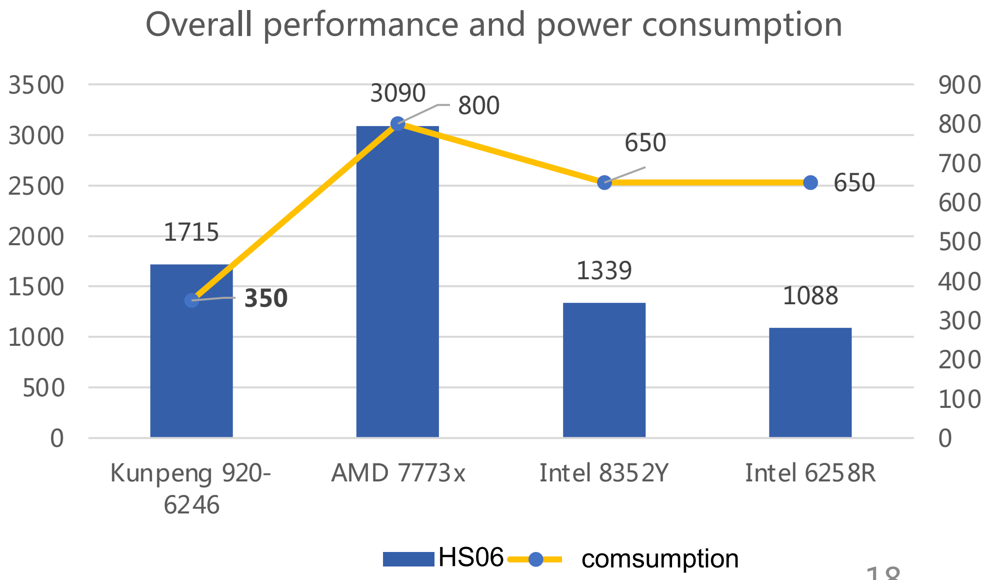
Power consumption variations during the execution of Corsika jobs



Backup – Arm Evaluation

- HS06 (HEP-SPEC06) test
  - Benchmark of HEP computing
  - ARM : Kunpeng 920@2.6G Hz, 48 cores*2
  - X86 : AMD EPYC 7773x@2.2G Hz, 64 cores*2
  - Intel Xeon 8352Y@2.20GHz, 32 cores*2
  - Intel Xeon 6258R@2.70GHz, 28 cores*2


HS06 of Single core
Kunpeng 920-6246
AMD 7773x
Intel 8352Y
Intel 6258R


Overall performance and power consumption
Kunpeng 920-6246
AMD 7773x
Intel 8352Y
Intel 6258R
HS06
comsumption