Grid Data Transfer Infrastructure for CEPC

IHEP operations, FTS4 tests and a CEPC validation plan

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Outline

REPORT OUTLINE

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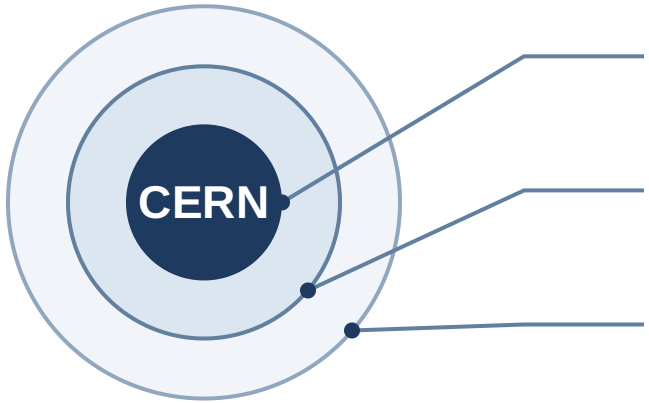
Introduction

CEPC transfer needs and IHEP experience

Why grid data transfer?

LHC data processing and storage exceed a single centre’s capacity.

Worldwide LHC Computing Grid (WLCG)



Tier-0 / CERN
Raw-data first copy and first reconstruction

Tier-1
Archive and reprocess

Tier-2
Simulation and analysis

Simplified core tier roles · original illustration based on CERN/WLCG

Workflows place jobs; transfers deliver data between sites.

CEPC plans distributed computing.

First-five-year estimates · CEPC TDR (2025)

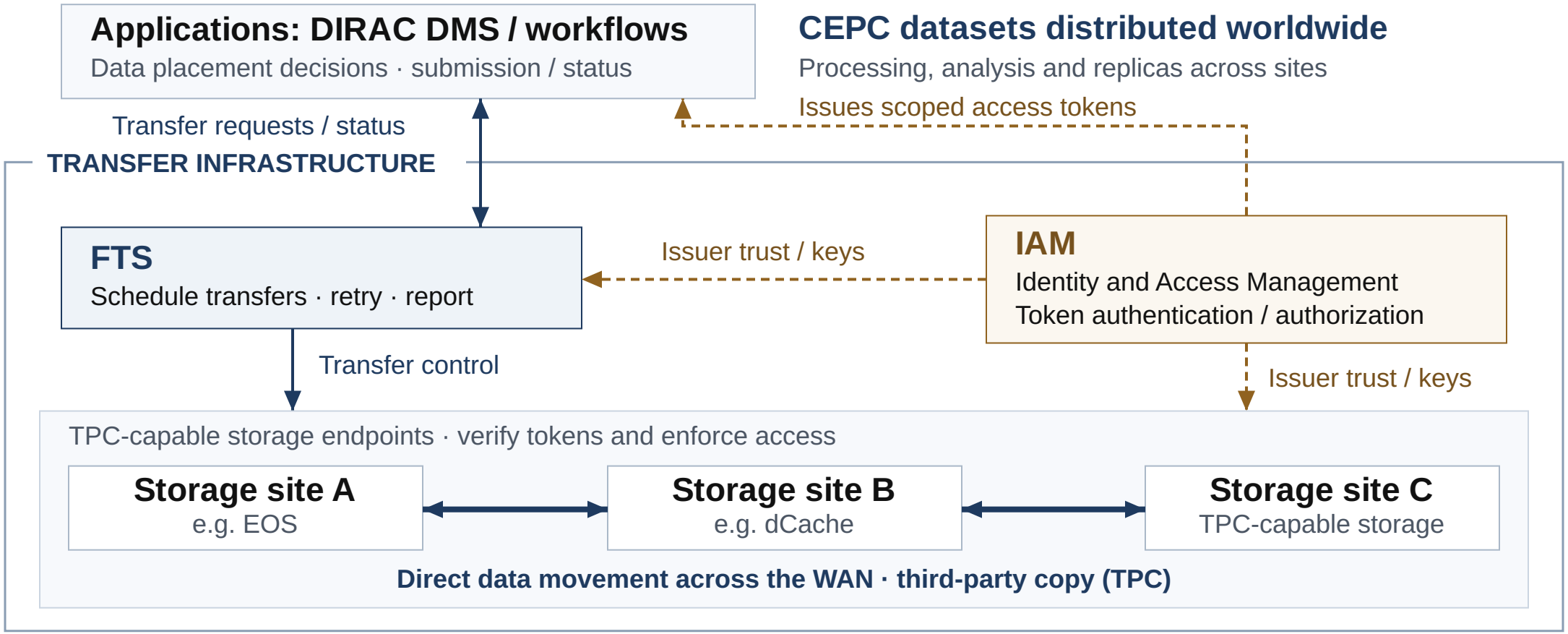
460 PB disk

460 PB tape

> Transfers deliver input datasets, return outputs and maintain replicas.

CEPC grid data transfer model

CEPC · WORLDWIDE DATASET DISTRIBUTION



Planned token-based transfer model for CEPC, shown with example storage sites.

JUNO: operating experience for CEPC

JUNO · OPERATING EXPERIENCE

IHEP-CC deploys and operates the FTS service for JUNO.

Over 10 years Serving JUNO since its construction phase.

Raw, simulation and analysis data transfers across four major sites.

JUNO · 2026 year to date · reported 14 Sep 2026

11.65 PB

Data transferred

6,333,642

Files transferred

Cumulative transfer volume and file count.

> The same IHEP service also supports CEPC.

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FTS4

From FTS3 operations to FTS4 qualification

Introduction **FTS4** TPC IAM Summary

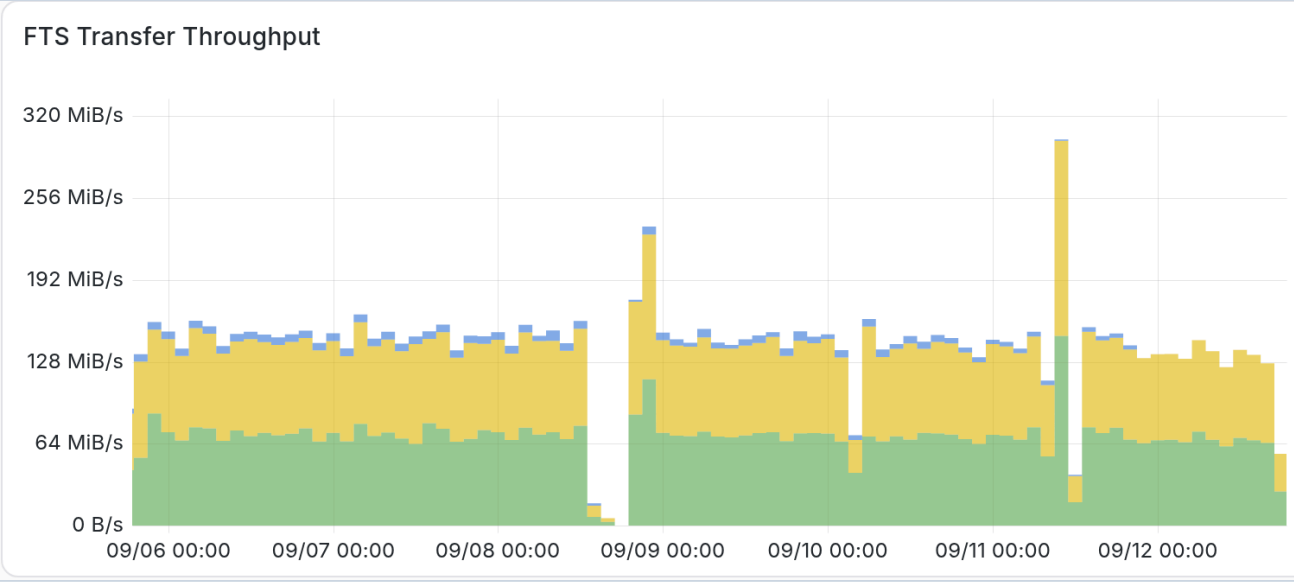
FTS3 operation and monitoring at IHEP

FTS AT IHEP · SERVICE AND MONITORING

FTS3 server 3.14.5 · dedicated RPM deployment · VOMS proxies in production

September 2026 service snapshot; JWT workflows are under test.

FTS events
fts-activemq
→ **ActiveMQ** →
MonPipe
IHEP · STOMP consumer
→ **Elasticsearch**
Shared service
→ **Grafana**



Operators can follow

Transfer volume, file counts, rates, success and failures.

Filter the full dashboard

By site, endpoint and workload.

Workshop snapshot · 6–12 Sep 2026

JUNO operations contribute to FTS development

JUNO operations exposed problems IHEP handled locally or with FTS developers. Joint work led to code fixes and features developed from accepted requests.

Issue in JUNO operations	Local response
Bursts strain storage endpoints.	Tune concurrency at host, storage and link levels.
Relay and normal replicas compete to write the same file.	Use a dedicated relay directory. Cleanup remains manual.

Proposed to FTS: reuse the first hop, or delete the relay copy after hop 2 succeeds.

LHCb explicitly cited the IHEP relay case in its cleanup discussion.

> Project support is available to invite FTS developers to IHEP over the next two years for deployment and upgrade discussions.

Why the transfer service needs FTS4

FTS4 · PREPARING FOR RUN 4

HL-LHC / Run 4, around 2030, brings more data to record and distribute.

50% of expected Run-4 transfer rates

DC27 planning target, subject to available hardware.

Larger workloads expose FTS3's design limits

Starved links and unpredictable priorities delay transfers. Scheduling and monitoring compete for database resources as queues grow.

> **FTS4 redesigns scheduling and the transfer engine**
>
> Designed to share capacity fairly and keep queued tasks progressing.

Sources: CERN HiLumi · Data Challenge 2027 · FTS4 for DC27

What changes in FTS4

FTS4 · CORE CHANGES

FTS4 redesigns the File Transfer Service for larger workloads.

Fair, explainable scheduling

Links, experiments and activities get defined turns and shares.

A deterministic order helps operators explain waiting times.

An engine for larger queues

PostgreSQL and reworked workers support larger queues.

Batch updates speed writes; consistent locking fixes identified deadlocks.

Persistent tape workflows

Per-endpoint requests and resilient polling support long recalls.

Failed polls can be retried; tape REST calls support token authentication.

Adaptive concurrency is in development; queue back-pressure is planned. Qualification continues.

IHEP's next steps for the FTS service

JUNO's 2027 Data Challenge

Real data	Real reproduction and RAW datasets via DIRAC → FTS.
Full workflows	IAM/JWT, tape recall and cross-site disk buffers.
Progressive load	Check routes, then aggregate load and short peaks; protect production.

Set sustained and peak loads from data volumes and available capacity.

In parallel: FTS4 service preparation

An isolated test bed is running; IHEP's service goal is 2027.

Two 50 MiB copies completed: VOMS and unmanaged JWT. Deployment awaits qualification.

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TPC

Direct data movement between storage sites

Introduction FTS4 **TPC** IAM Summary

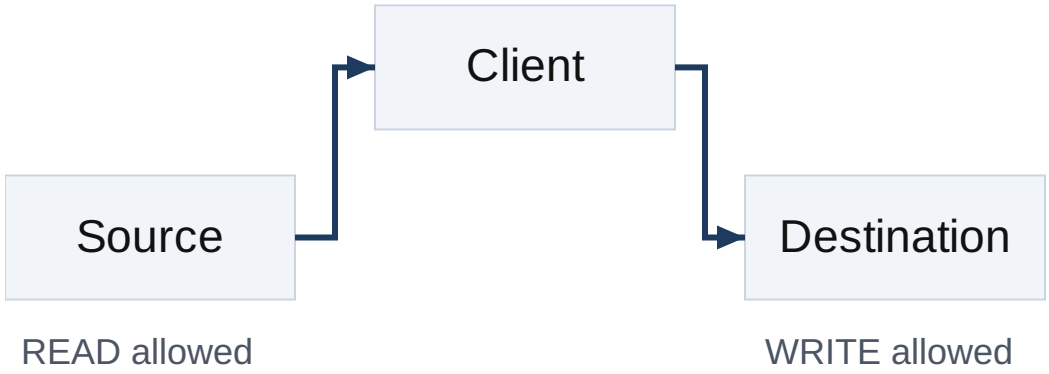
Third-party copy keeps bulk data off the client

THIRD-PARTY COPY · DATA AND CONTROL

FTS coordinates the copy; storage endpoints move the files.

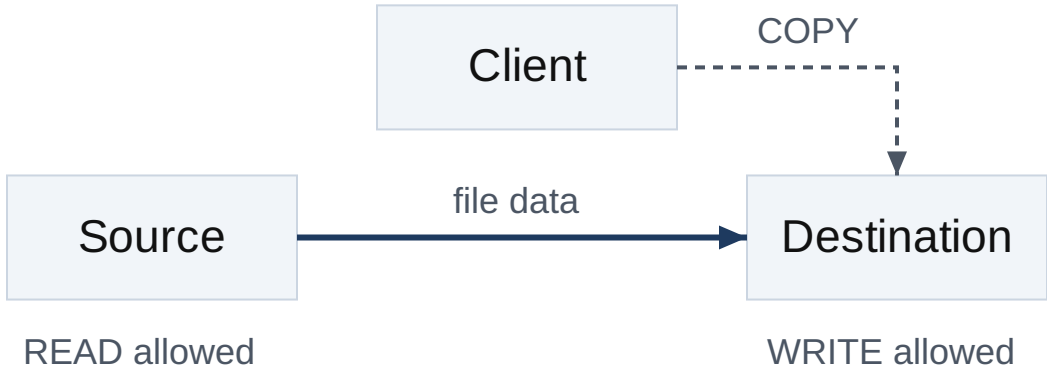
Local copy

Download, then upload



Third-party copy (TPC)

HTTP pull example



Avoid the client relay and its bandwidth bottleneck.

WLCG TPC families HTTP(S)-TPC (WebDAV COPY) · native XRootD-TPC

The “third party” is the controller, not a third storage site. Endpoints enforce access permissions.

JUNO connects different stores through HTTP-TPC

Different storage backends, a shared HTTP(S)-TPC / WebDAV interface.

2022 · Macaroon support

Full support across IHEP's TPC endpoints

Client uses a VOMS proxy

↓

Storage issues a restricted Macaroon

↓

Bearer token authorizes TPC access

The holder can add caveats to narrow rights.

2023 · WLCG JWT support

IHEP begins supporting IAM-issued tokens

Client authenticates via IAM

↓

IAM issues a scoped WLCG JWT

↓

Trusted storage verifies and enforces it

OAuth 2.0 / OIDC workflow; can avoid a user VOMS proxy for resource access.

These are acquisition workflows, not login requirements of the token formats. File data move between storage endpoints.

September 2026: FTS3 production uses VOMS; JWT workflows remain in testing.

Sources: FTS HTTP-TPC · dCache Macaroons · INDIGO IAM · WLCG JWT profile

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IAM

Identity, tokens and CEPC plans

Introduction FTS4 TPC **IAM** Summary

IAM connects identity to scoped access

IDENTITY AND ACCESS MANAGEMENT · TRUSTED ISSUERS

IAM issues scoped tokens to applications; storage enforces file permissions.

Synthetic decoded payload

```
{
  "iss": "https://iam.example.org",
  "sub": "example-subject-01",
  "aud": "https://storage.example.org",
  "iat": 1792828800,
  "exp": 1792832400,
  "jti": "example-token-01",
  "wlcg.ver": "1.0",
  "scope": "storage.read:/data/cepc"
}
```

Illustrative payload, not a real credential. No signature.

Operation + path

storage.read:/data/cepc

Read online files and stat.

storage.create:/data/cepc/out

Create files and directories; cannot overwrite or delete existing data.

storage.modify:/data/cepc/out

Also allow overwrite and delete.

Other scopes shown separately; payload grants read only.

FTS validates its own access and controls copies. Storage checks audience and scope; payload moves by TPC.

IHEP operates IAM for HERD

HERD · DEPLOYED IAM SERVICE

IHEP deploys and operates INDIGO IAM for HERD.

HERD's public issuer https://herd-iam.ihep.ac.cn/

Token-service interface

OAuth 2.0 and OpenID Connect for token-based applications.

VOMS-AA compatibility

Membership attributes for existing grid credentials.

Sign-in choices

Institutional and federated sign-in, alongside local credentials.

Observed 23 Oct 2026: INDIGO IAM login service and VOMS-AA v1.14.2; public discovery and login pages available.

IAM's future at IHEP

LOCAL PLANS · JWT MIGRATION AND NEW SERVICES

JUNO

Complete JWT migration before JUNO's DIRACx upgrade.

Every participating site

Trust the issuers and support file read/write access.

Monitoring by site

JWT authorization failures; FTS results.

CEPC

Plan IHEP-deployed CEPC-IAM for TPC with JWT authorization.

Identity and authorization

Include both in the initial service design.

Transfer roles

FTS controls copies; storage moves files.

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Summary

From JUNO rehearsal to CEPC validation

Introduction FTS4 TPC IAM **Summary**

IHEP's transfer roadmap

IHEP · PLANNED LOCAL MILESTONES

Local targets for the DIRAC and transfer workflow.

End 2026

DIRAC8 → DIRAC9

Upgrade at IHEP.

February 2027

DC27

Data Challenge.

Mid-2027

IAM/JWT-authorized TPC

Fully replace legacy VOMS-proxy TPC.

End 2027

DIRAC9 → DIRACx

Upgrade at IHEP.

All milestones are planned. DC27 precedes full JWT migration and does not wait for FTS4.

Summary

- **Introduction**

  CEPC needs distributed transfers; IHEP brings JUNO operating experience.

- **FTS4**

  New scheduling, queue handling and tape workflows remain under qualification.

- **TPC**

  Storage endpoints enforce access and move files directly between sites.

- **IAM**

  IHEP operates HERD IAM and plans CEPC-IAM with JWT-authorized TPC.

Thank you!

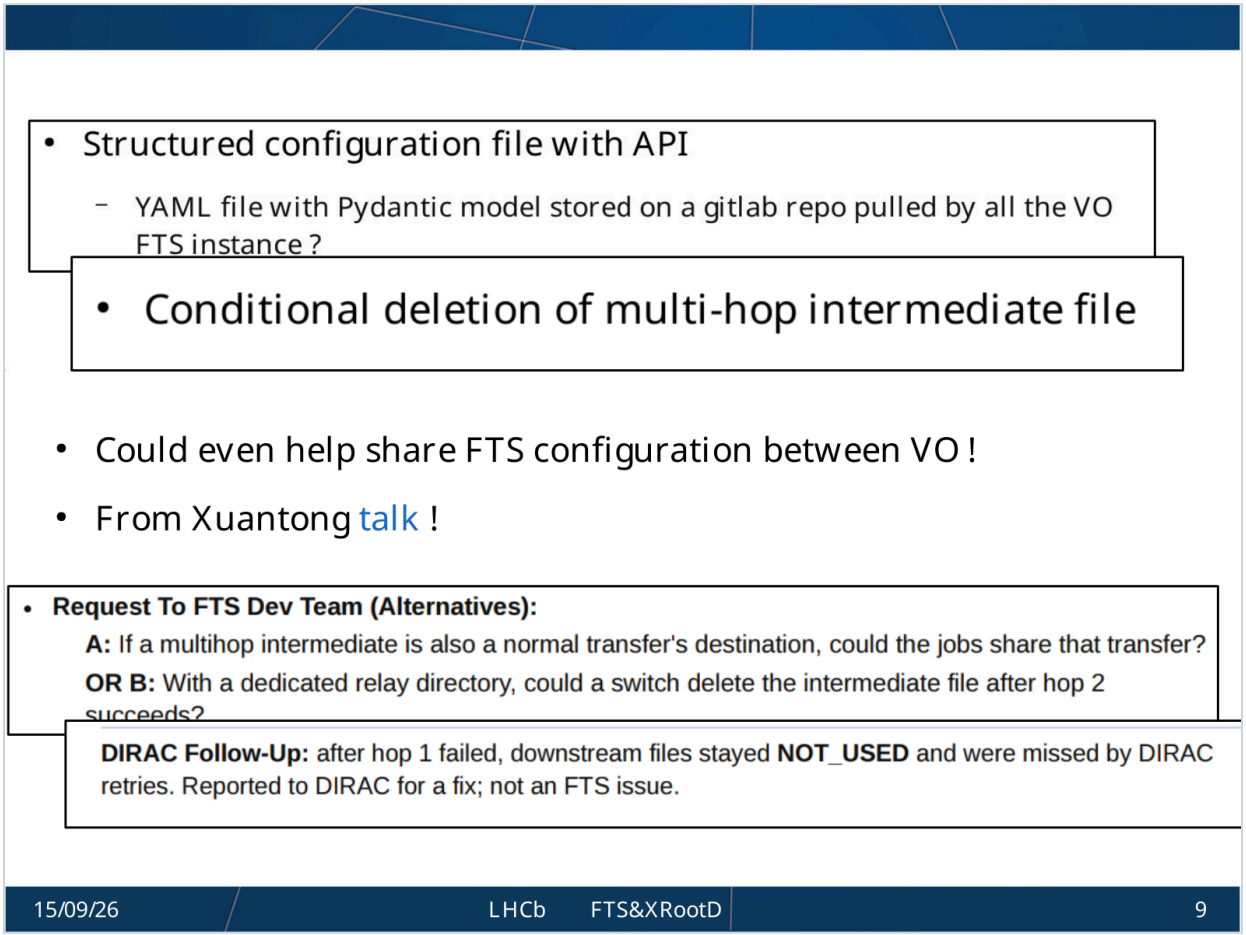
SUPPLEMENTARY MATERIAL

Backup

Additional details and references

LHCb explicitly cited the IHEP multihop case

COMMUNITY · EXPLICIT CITATION



“From Xuantong talk !”

IHEP's operational example was reused in LHCb's discussion of conditional relay-file cleanup.

Cleanup was already on LHCb's 2025 list. This is a citation of the 2026 case, not a claim of invention or implementation.

Source: Christophe Haen, LHCb <3 FTS[34] · 15 Sep 2026 · pp.8–9

What the numbers describe

BACKUP · MEASUREMENT SCOPE

SYSTEM / DATE	EVIDENCE	SCOPE AND LIMITS
JUNO 2026 YTD; 14 Sep report	11.65 PB 6,333,642 files transferred	Cumulative transfers; not unique datasets
JUNO Same reporting period	81.56% per attempt 97.38% with ≤3 retries	Different denominators; not service availability
IHEP FTS4 September 2026	2 × 50 MiB VOMS / unmanaged JWT	Functional checks; not a load benchmark
CERN / DC27 September 2026 findings	40k concurrent transfers 20M queued requests	40k test: expected failures; 20M queue: target

Sources: FTS at IHEP · pp.6, 21; FTS4: State of Testing Affairs · pp.2, 5–8

IHEP test scope and upstream dependencies

BACKUP · IHEP/JUNO PROPOSALS

CANDIDATE LOAD	ONE-WAY	AGGREGATE	DURATION
Sustained	20 Gb/s	40 Gb/s	About two weeks
Extreme	≥40 Gb/s	≥80 Gb/s	Short peaks within 1–2 days

JUNO/IHEP proposals, subject to capacity and production protection. These are not CEPC requirements.

Checks and dependencies

Managed-token exchange/renewal, tape, cancellation and multihop cleanup need explicit checks.

FTS-2319: “Delete intermediary multi-hop files” is on the September Post-DC27 plan. No IHEP authorship or delivery claim.

FlowController timing differs between reports; this plan does not depend on a promised date.

Sources: FTS at IHEP · pp.17–19; FTS status and plans · slide 6

Sources

BACKUP · REFERENCES

TDR CEPC Reference Detector Technical Design Report

CEPC Study Group · October 2025 · Table 13.1; §§13.6–13.7

IHEP FTS Status and Future Plan at IHEP

Zhang et al. · 14 Sep 2026 · pp.4, 6, 8, 17–21

QA FTS4: Establishing QA Procedures

Patrascoiu · 15 Sep 2026 · pp.7–15, 23–26

DC27 Data Challenge 2027

Ellis · 15 Sep 2026 · pp.3, 8–9

Event CEPC2026, Shanghai

24 October 2026 · Offline Computing & Software · 10:20–10:40

Tests FTS4: State of Testing Affairs

Patrascoiu · 15 Sep 2026 · pp.2, 5–8

LHCb LHCb <3 FTS[34]

Haen · 15 Sep 2026 · pp.8–9

Plans FTS4 for DC27: What We Deliver and What Comes Next

Arsuaga-Rios · September 2026 · slides 1–3, 6–7