FTS Status and Future Plan at IHEP

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1. FTS Use Cases at IHEP

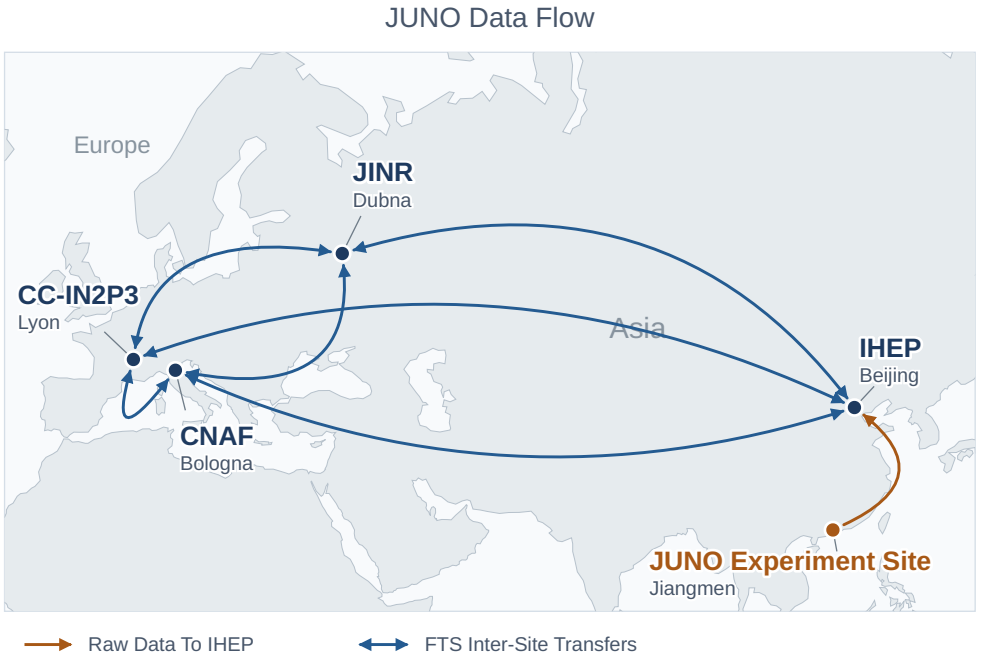
FTS Instance at IHEP

FTS Software Versions

Component	Version
fts-server	3.14.5
fts-optimizer	3.14.5
fts-qos	3.14.5
fts-token	3.14.5
ftstokenhousekeeperd	3.14.5
fts-activemq	3.14.5
FTS REST / Web monitoring	3.14.3
GFAL2	2.23.5

- A dedicated FTS3 instance; RPM deployment. https://fts3.ihep.ac.cn:8449
- Supports JUNO (primary user), HERD and CEPC.
- Production uses VOMS proxies; JWT-based transfers are supported but used only for testing.

JUNO Experiment with FTS



Stored Data: ~37.9 PB (Including Replicas)

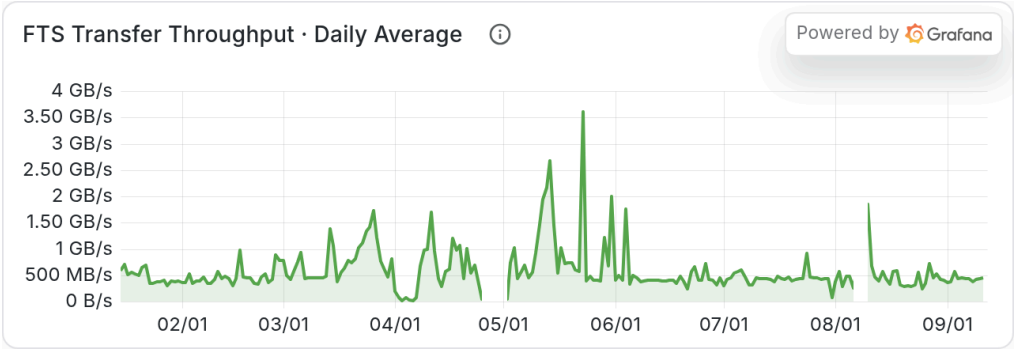
Disk 20.2 PB · Tape 17.7 PB · 14 Sep 2026

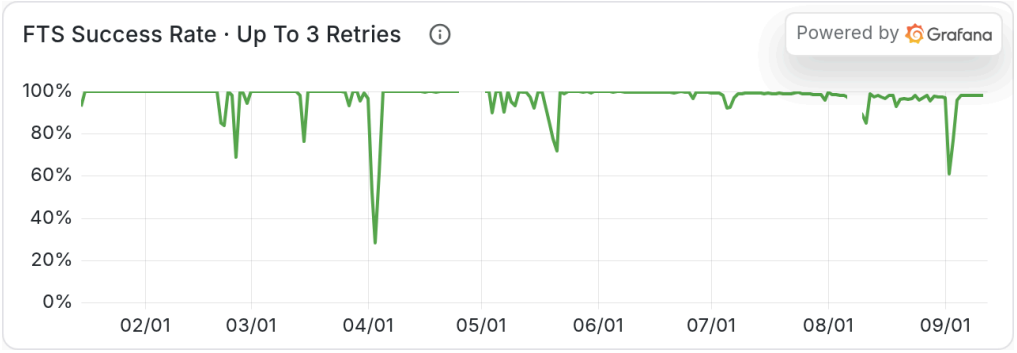
The Jiangmen Underground Neutrino Observatory (JUNO) is a multipurpose neutrino observatory with a broad physics program.

- **Raw data** go from Jiangmen to IHEP, then through FTS to JINR, CC-IN2P3 and CNAF.
- FTS distributes experiment data, such as **reconstruction and analysis products**, across all four computing sites.
- JUNO's FTS jobs are submitted and managed by **DIRAC**.

JUNO FTS Operations in 2026

FTS Transfer Status At IHEP This Year



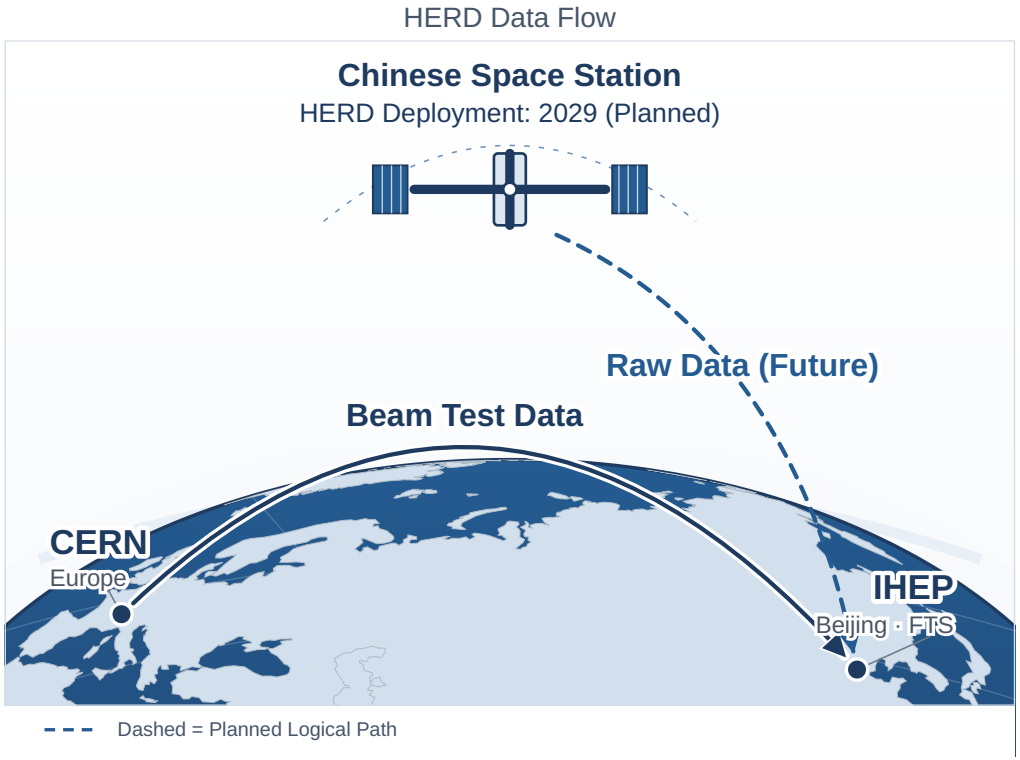


JUNO Transfers This Year

Metric	Value
Per-Attempt Success	81.56%
Success (⩽3 Retries)	97.38%
Data Transferred	11.65 PB
Files Transferred	6,333,642

- Steady **raw-data traffic**, with peaks from periodic bulk production.
- FTS is generally reliable: stable raw-data transfers and high success rates after tuning during bursts.

HERD Experiment with FTS



HERD is a space-based high-energy cosmic-ray observatory for dark matter searches, precision cosmic-ray measurements, and all-sky gamma-ray surveys.

- Planned for **2029**; FTS currently handles **CERN → IHEP beam-test data**.
- Future FTS use: raw-data distribution from IHEP to **Chinese and European partners**, plus production transfers.
- **Rucio** submits and manages HERD's FTS jobs.
- FTS total to date: **778 GB** in **1,563 files**.

FTS Operation Issues

Here we share issues encountered at IHEP and the workarounds we used.

Issue 1: Multihop Transfers With DIRAC

- **Background:** poor IHEP–JINR connectivity (Sep 2025–Mar 2026) led us to relay transfers via CNAF.
- **DIRAC Multihop: IHEP → CNAF → JINR** in one FTS job; hop 2 starts only after hop 1 succeeds.
- **Collision:** concurrent CNAF and JINR replicas competed to write the **same CNAF file**, causing failures.
- **Workaround:** use a **dedicated relay directory**; the leftover temporary files still need **manual cleanup**.
- **Request To FTS Dev Team (Alternatives):**

  A: If a multihop intermediate is also a normal transfer's destination, could the jobs share that transfer?

  OR B: With a dedicated relay directory, could a switch delete the intermediate file after hop 2 succeeds?

DIRAC Follow-Up: after hop 1 failed, downstream files stayed **NOT_USED** and were missed by DIRAC retries. Reported to DIRAC for a fix; not an FTS issue.

Issue 2: Concurrency Control During Transfer Bursts

JUNO production is batch-based: **tens of thousands of transfers**, typically **~200 MB per file**. We cap concurrency to protect storage.

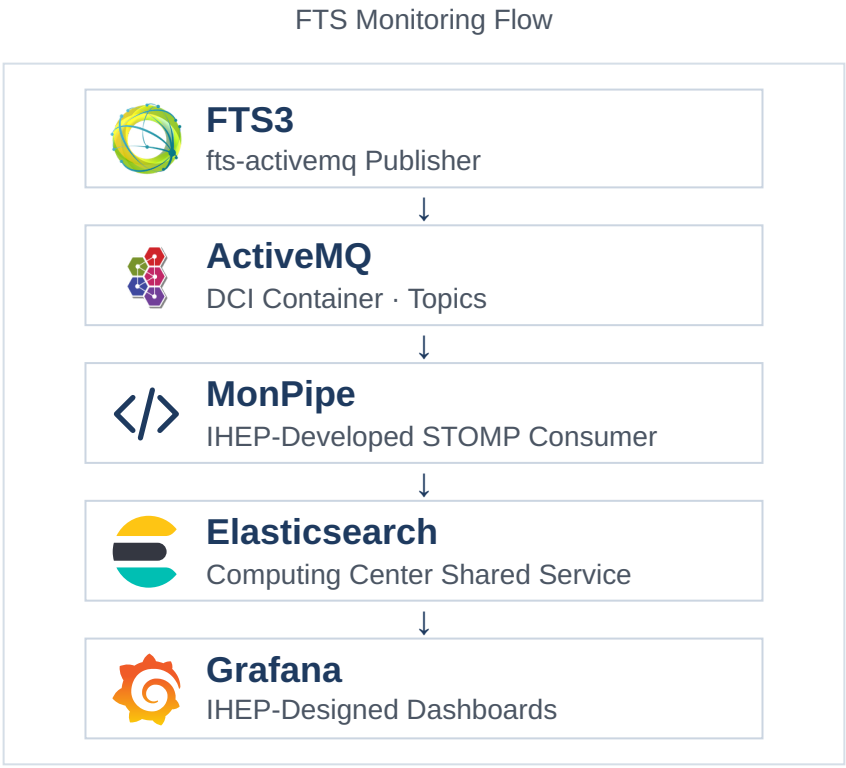
Concurrency Controls

Level	Configuration	Concurrency Limit
FTS Host	fts3config **MaxUrlCopyProcesses**	Total url-copy processes per host
Storage (SE)	Config UI: Storage Configuration	Separate inbound / outbound limits
Link (SE Pair)	Config UI: Link Configuration	Active transfers for one SE pair

- **Operational Cost:** the limits work well. To favour **IHEP → CNAF**, we raise its cap and lower the IHEP → IN2P3/JINR caps.
- **Question To FTS Dev Team:** could each destination get a **configurable percentage of a source SE's outbound transfer slots**?

2. FTS Monitoring Developed at IHEP

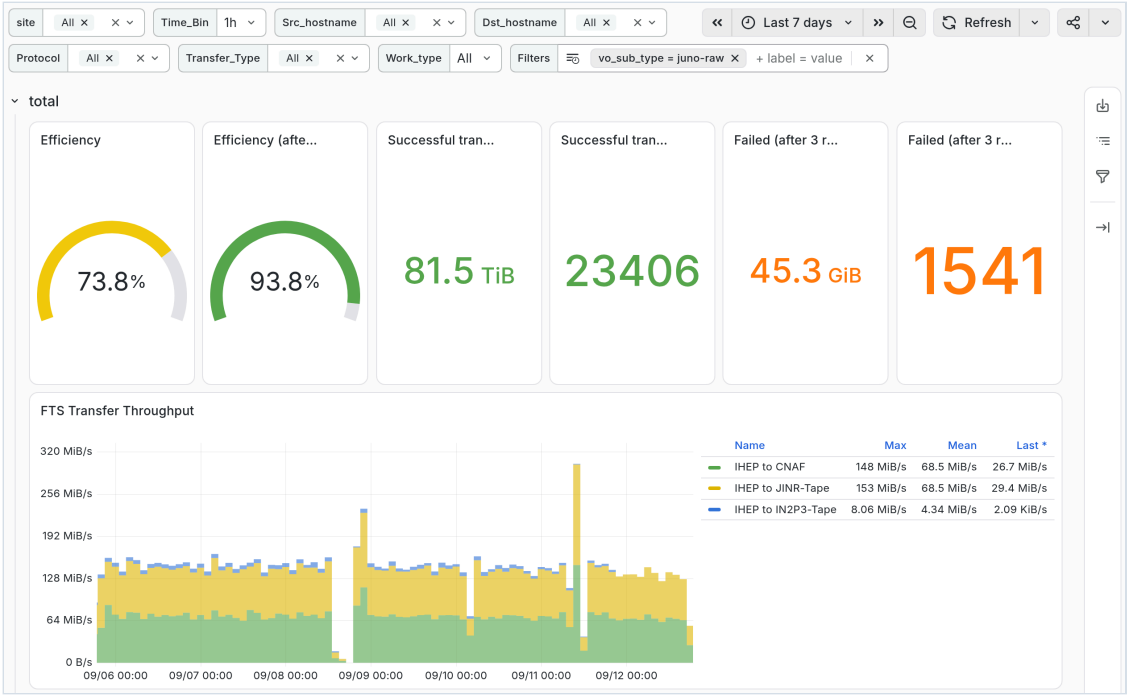
FTS Transfer Monitoring System at IHEP



- FTS publishes to ActiveMQ **topics** so multiple consumers can receive the events. We would like **CERN FTS monitoring** to retain a copy too.
- ActiveMQ, MonPipe and Grafana are **DCI-managed containers**. Elasticsearch is a **shared IHEP Computing Center service**.
- Ruby dependency compatibility issues with Logstash prompted us to develop **MonPipe**, a Python STOMP consumer with flexible processing and simpler configuration.
- MonPipe adds **directory-based workload tags** to completion records.
- We build our own **Grafana dashboards**, rather than use CERN's, to show the metrics most relevant to our operations.

FTS Transfer Monitoring

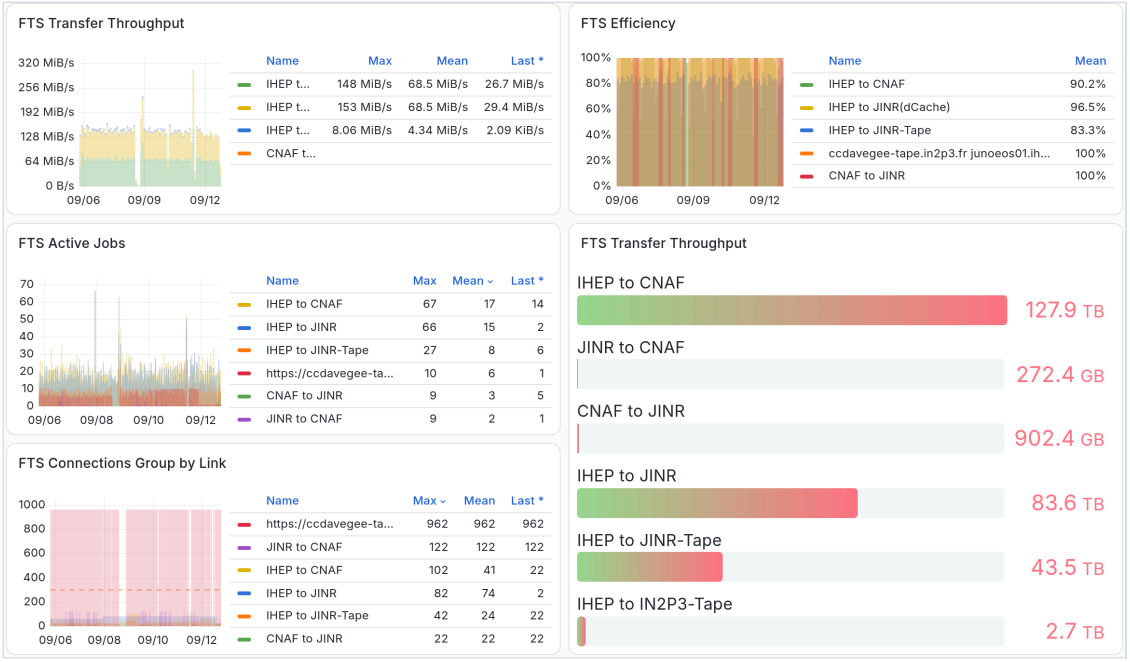
Dashboard For Admins



- An overview of FTS transfers for a **selected VO**, with filters for sites, endpoints and protocols.
- Shows **success rates, transferred volume and file counts**, with time-dependent views of transfer performance.
- Directory-derived tags from MonPipe let us filter by **data type or workload**, such as raw data and re-production.

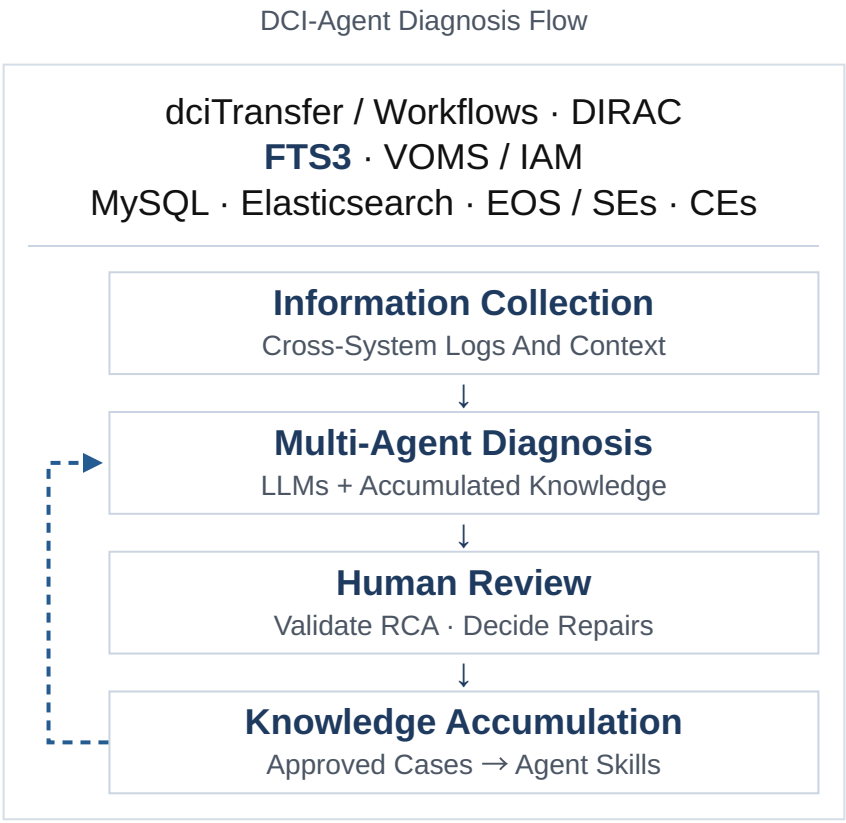
Raw Data Transfer Monitoring

Dashboard For Shifters



- Designed for **experiment shifters**, with a focus on raw-data transfer performance.
- Alongside volume and performance trends, it shows the latest **active transfers and FTS connections by link**.
- The same dashboard's **Server Resource Summary** adds host load, filesystem usage and disk I/O for source-side checks.

AI-Assisted Diagnostics System



DCI-Agent is our in-house AI system for diagnosing distributed computing problems across systems and sites.

- For an **FTS incident**, collect relevant logs across upstream and downstream services for a joint LLM diagnosis.
- **Multiple agents** combine cross-system evidence with accumulated service knowledge to identify likely root causes.
- **Humans decide:** validate the diagnosis and choose whether to execute the proposed repairs.
- Accepted cases become **shared knowledge and agent skills**, helping diagnose similar transfer issues next time.

A Real Case: AI-Assisted Diagnostics For FTS

JUNO Production Transfer Case

Step	Finding
Symptom	Widespread FTS failures during a JUNO production campaign.
AI Analysis	Connection/authentication dominated the stage timings; **IHEP EOS** was suspected.
Human Check	An **OpenSSL library version issue** was identified on the EOS side.
Fix / Outcome	Upgrading the OpenSSL library used by EOS restored transfers.

Earlier in 2026, a JUNO production campaign saw widespread FTS failures. This case shows how **DCI-Agent** helped narrow the cause.

- AI pointed to **EOS connection/authentication**, but did not identify the exact OpenSSL issue.
- Even with **incomplete evidence**, FTS stage timings narrowed the search for operators.
- Richer logs and this reviewed case **could shorten future investigations**.

3. Data Challenge 27 Plans

Lessons From DC24

DC24 Test Setup

Item	Approach
Load Injector	In-house tool using the FTS REST API
Test Data	Synthetic files, **500 MB–5 GB**
Transfer Setup	**VOMS proxies**; transfers between disk SEs
Hourly Injection	Example budgets: **~0.45 / 0.9 / 1.8 TB/h**

- Our **in-house load injector** drove the JUNO challenge alongside DC24, with configurable volume and injection intervals.
- Tests on the upgraded **IHEP–CNAF/IN2P3** paths met the transfer rates JUNO expected at the time.
- **Not Tested In DC24:**
  - IAM/JWT authentication
  - Real experimental data
  - DIRAC-driven FTS workflows

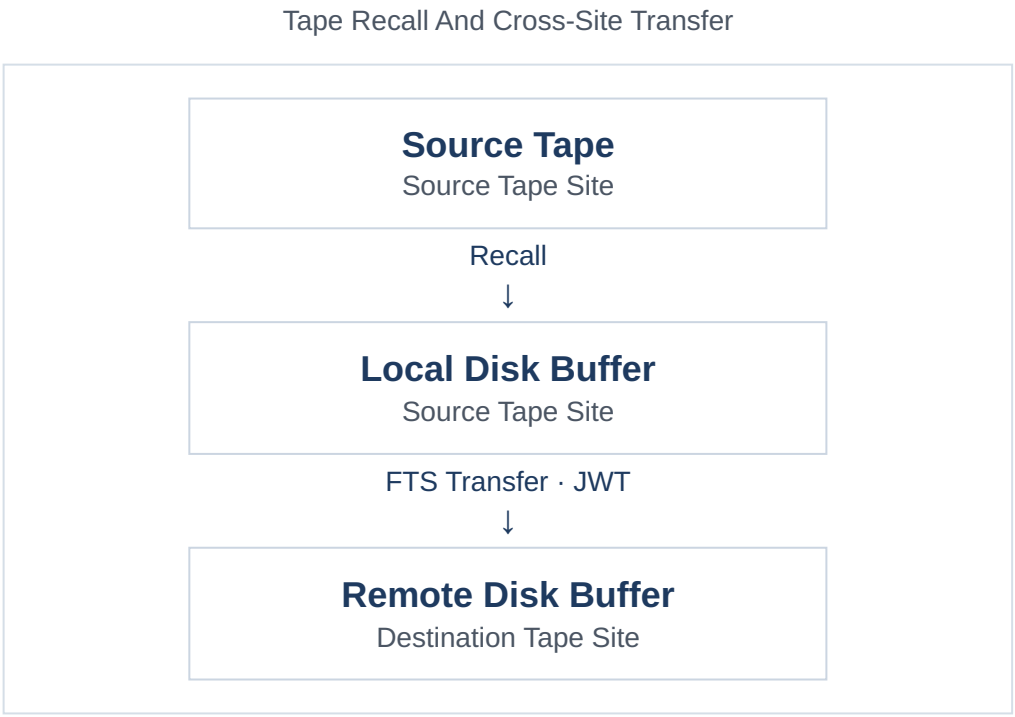
DC27 Network Targets

Candidate Routes And Targets

Item	Starting Point
CNAF / IN2P3	LHCONE
JINR	LHCOPN / Separate VLAN
One-Way Load	**~20 Gbps** Extreme: ⩾**40 Gbps** (2×+)
Aggregate Load	**~40 Gbps** Extreme: ⩾**80 Gbps** (2×+)
Test Window	Baseline: **~2 Weeks** Extreme: **1–2 Days** Short Sessions Only

- Refine sustained targets from **real transfer volumes**, using **3–4× normal bandwidth**. Extreme tests aim for ⩾2× those targets, subject to capacity.
- Use an early **pre-challenge** to validate route choices. Test individual channels first, then aggregate traffic.
- Reserve **short peak sessions within a 1–2-day window**, while production continues.

DC27 Storage And Dataset Targets



- Use **recent real reproduction datasets** with **DIRAC → FTS** submission; include RAW-data tests.
- Test **IAM/JWT authentication** as part of the end-to-end workflow, not only VOMS proxies.
- Cover **every storage instance** via separate URLs, prioritising production storage and checking buffer space.
- Test **tape recall and cross-site buffer transfers**, with short peak sessions in the selected 1–2-day window while production continues.

4. FTS4 Status

FTS4 Test Bed

Initial Validation

Check	Result
REST / Web UI	Available; HTTP 200 verified
VOMS Proxy	**FINISHED · 50 MiB** IHEP EOS → IHEP EOS
JUNO IAM JWT	**FINISHED · 50 MiB** CNAF → IN2P3 Unmanaged tokens

- A dedicated test bed runs **FTS4 4.0.0 development RPMs** on AlmaLinux 9 with **PostgreSQL 16**.
- **Functional validation only:** these small transfers do not establish throughput, scale or production readiness.
- **Remaining work:** endpoint-specific token compatibility, managed-token renewal/exchange, scale/tape tests and production security hardening.

Summary

- **FTS3 operations:** support JUNO production and HERD beam tests; safer multihop handling and simpler destination prioritisation are operational priorities.
- **FTS monitoring:** track transfer performance, support cross-system diagnosis and reuse human-reviewed knowledge.
- **DC27:** test what DC24 did not cover: real data, DIRAC and JWT. Add tape workflows and short peak sessions while production continues.
- **FTS4:** initial VOMS and JWT transfer checks have succeeded; broader interoperability and readiness validation comes next.

Thank You!