# Monitoring System for JUNO Distributed Computing Infrastructure and Services

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# Outline

Introduction for JUNO and JUNO DCI

Architecture of Monitoring System

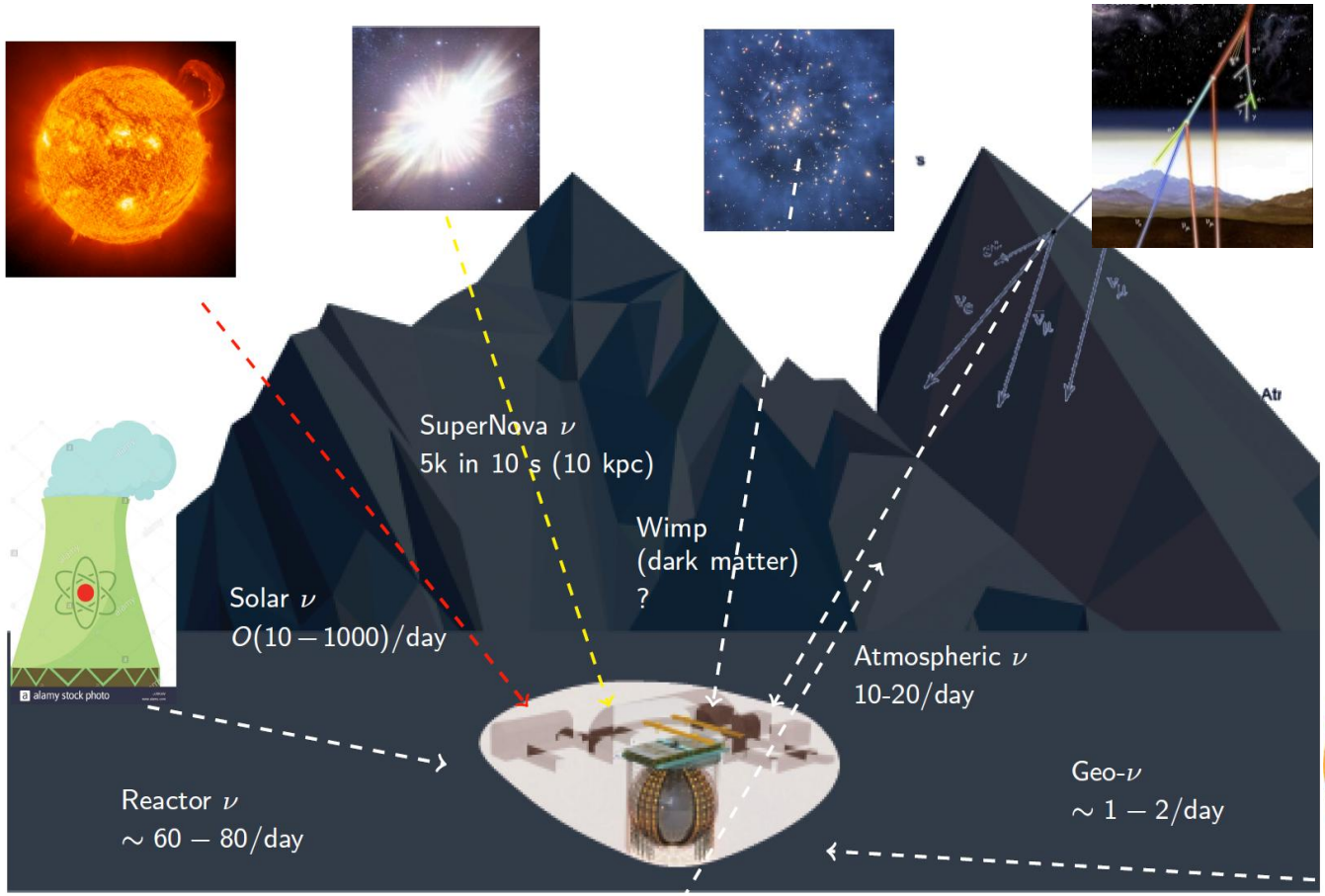
Applications

Future Plans

Summary

# JUNO Experiment

**Jiangmen Underground Neutrino Observatory (JUNO) is a multi-purpose neutrino experiment located in South China.**

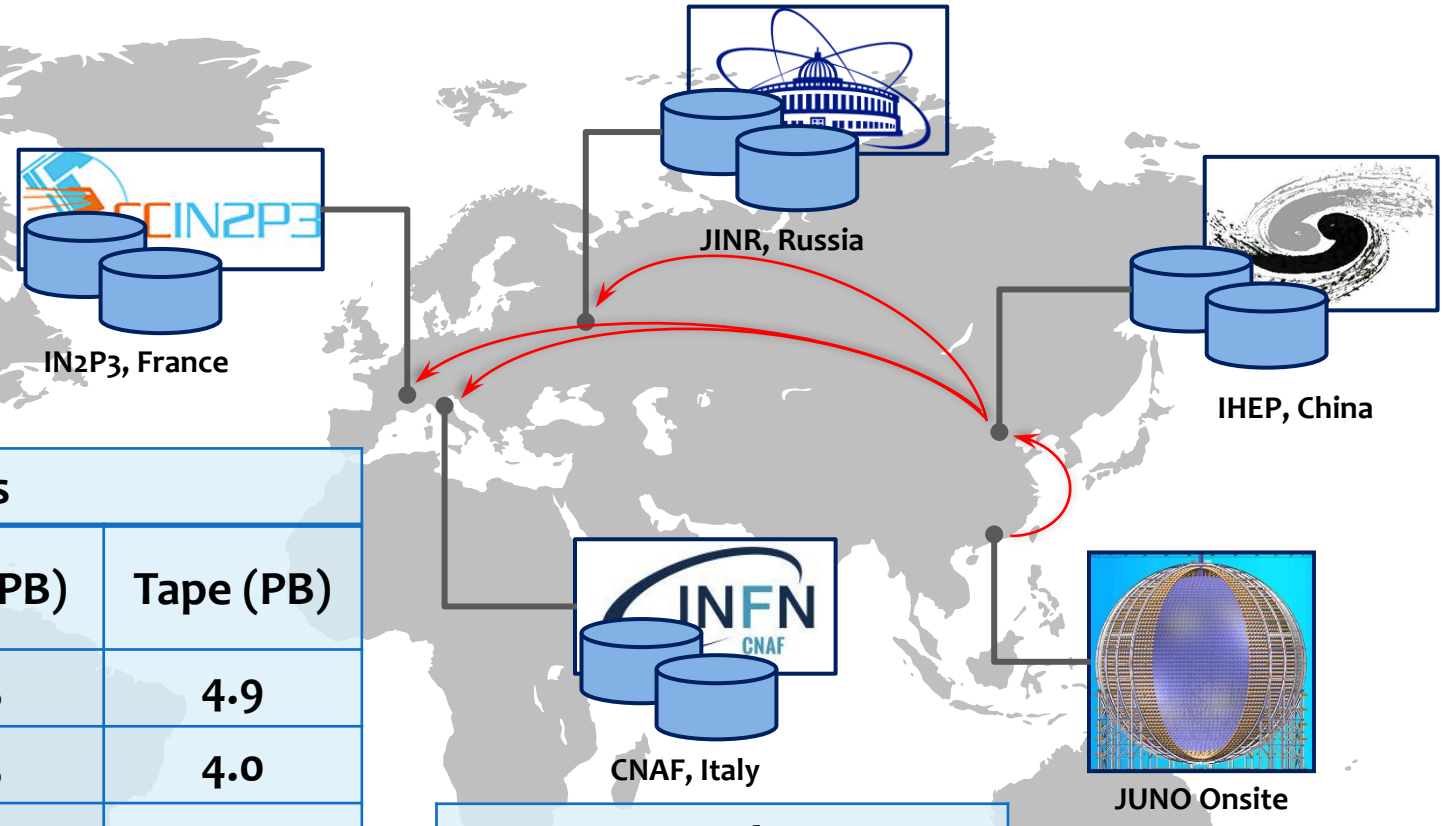



- Many physics programs
  - Reactor neutrinos
  - Solar neutrinos
  - Atmospheric neutrinos
  - Supernova burst neutrinos
  - Diffuse supernova neutrino background
  - Geo-neutrinos
  - Exotic neutrinos
  - Nucleon decay

# JUNO Distributed Computing

**Distributed Computing in JUNO:**

- ✓ Raw data distribution
- ✓ MC data production




| Site Resources | | | |
|---|---|---|---|
| | CPU (KHS06) | Disk (PB) | Tape (PB) |
| IHEP | 151 | 3.5 | 4.9 |
| CNAF | 5.0 | 5.3 | 4.0 |
| IN2P3 | 19.2 | 0.1 | 3.0 |
| JINR | 48 | 2.4 | 5.0 |
| Total | 223.3 | 11.3 | 16.9 |

| Data Volume | |
|---|---|
| Raw data | ~5.2 PB/year |
| Other data | ~0.8 PB/year |

# We Need Monitoring

**JUNO distributed computing infrastructure was lack of monitoring before 2024,**

- **An independent and centralized SAM (Site Availability Monitor) test service to probe sites status.**
  - We had a computing elements SAM test depends on DIRAC jobs and used DIRAC monitoring element as visualization, but the function was limited.
- **An independent dashboard collecting and visualizing DCI services status.**
  - DIRAC components, FTS3 jobs, or other services status was not collected.
  - Site status metrics collected by each site self-exposing is weak and independent.
- **Regular site running status reports and performance estimation.**

# And More...

**We need active tests for probing service availability or performance.**

## Site Availability Monitor (SAM) Test

Scheduled SAM test jobs for probing CE and SE availability.

## Third Party Copy (TPC) Test

Scheduled transfer jobs with different TPC modes.

# Monitoring System Architecture

**Monitoring System**

## Log Collection

- Machines
- Site Services
- Grid Midware
- Data Transfer

## Data Storage

- Log data
- Active probing tasks data

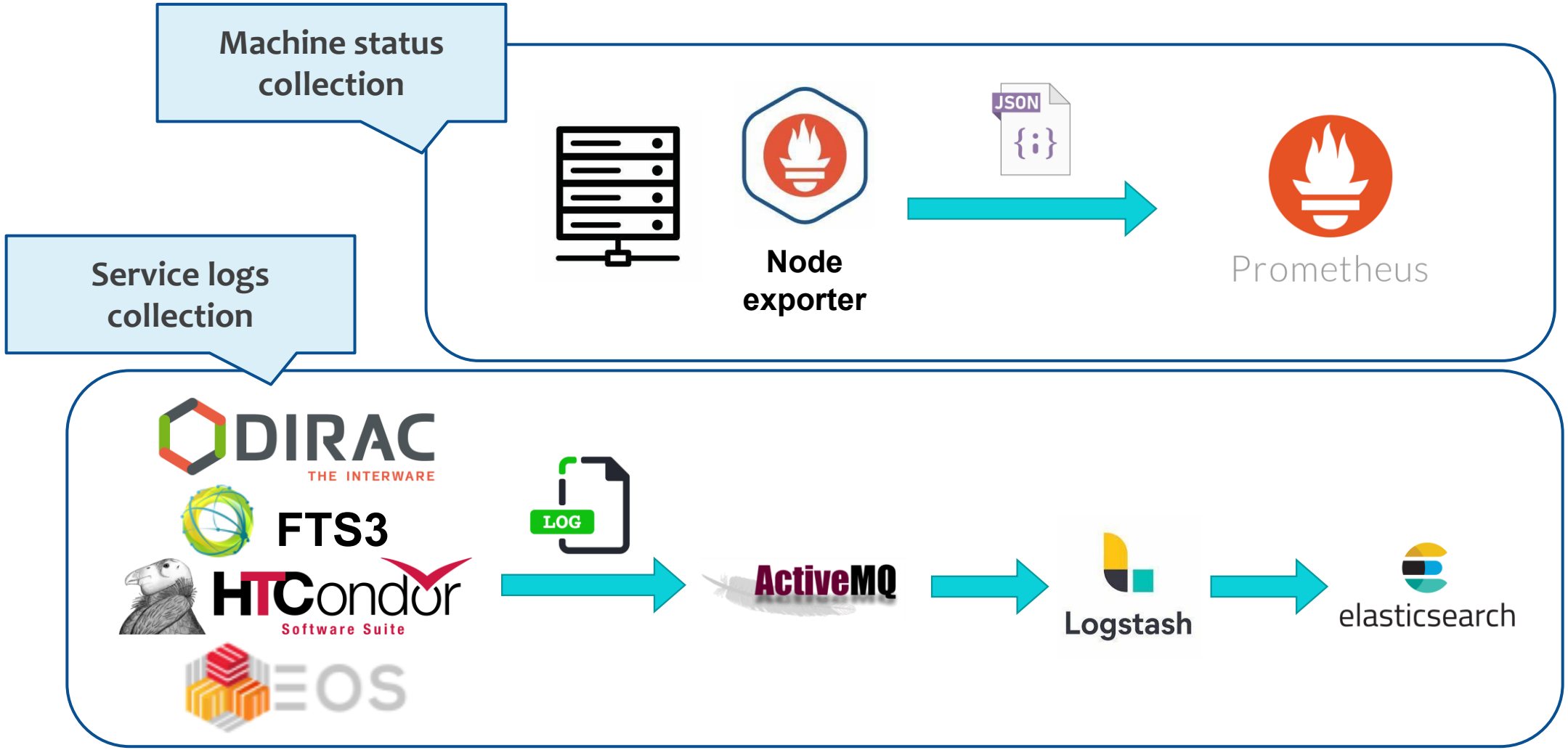
## Visualization

- Running status
- Accounting
- Active tasks management

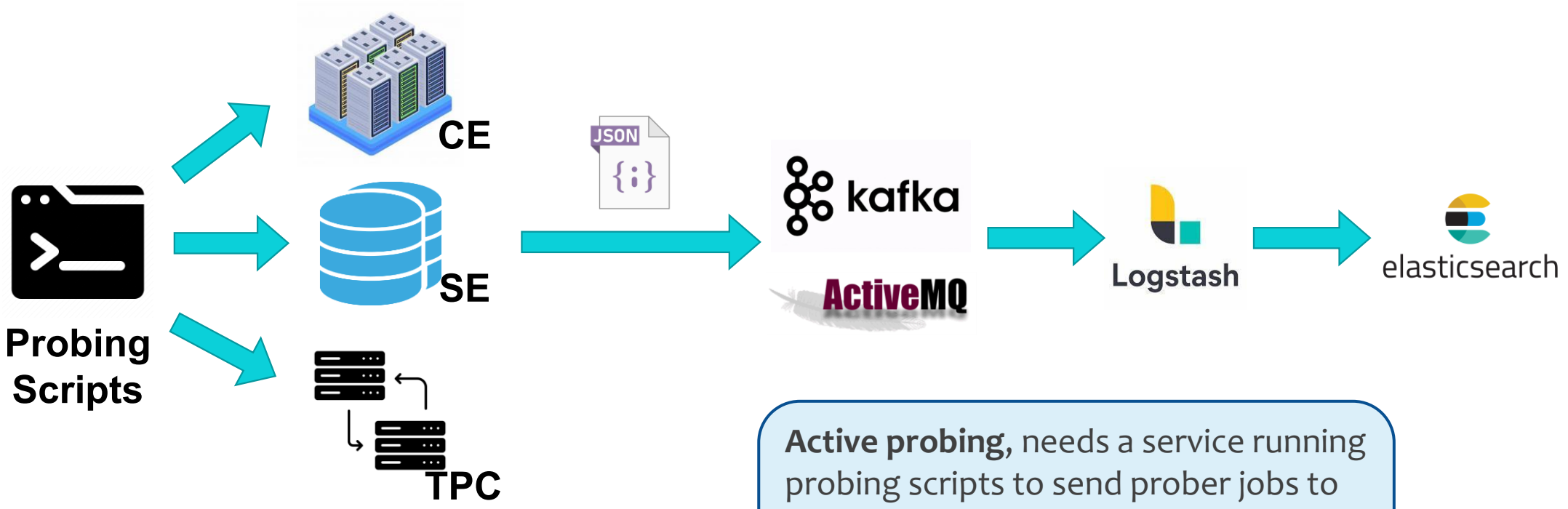
## Issues Handling

- Issues recognition
- Alerting
- Task retry

# Log Collection



# Active Probing




**Active probing**, needs a service running probing scripts to send prober jobs to collect status and logs.

- ✓ Site running status, TPC services status, etc..

# Metrics for Probing Scripts

## CE metrics (80+):

- Connection, SSL handshake, certificate check,
- Computing environment, experiment software, apptainer, etc.

## SE metrics (70+):

- Connection, SSL handshake, certificate check,
- File accessing, file listing, file writing, file deleting,
- Xrootd/WebDAV protocols functions from local access, etc.

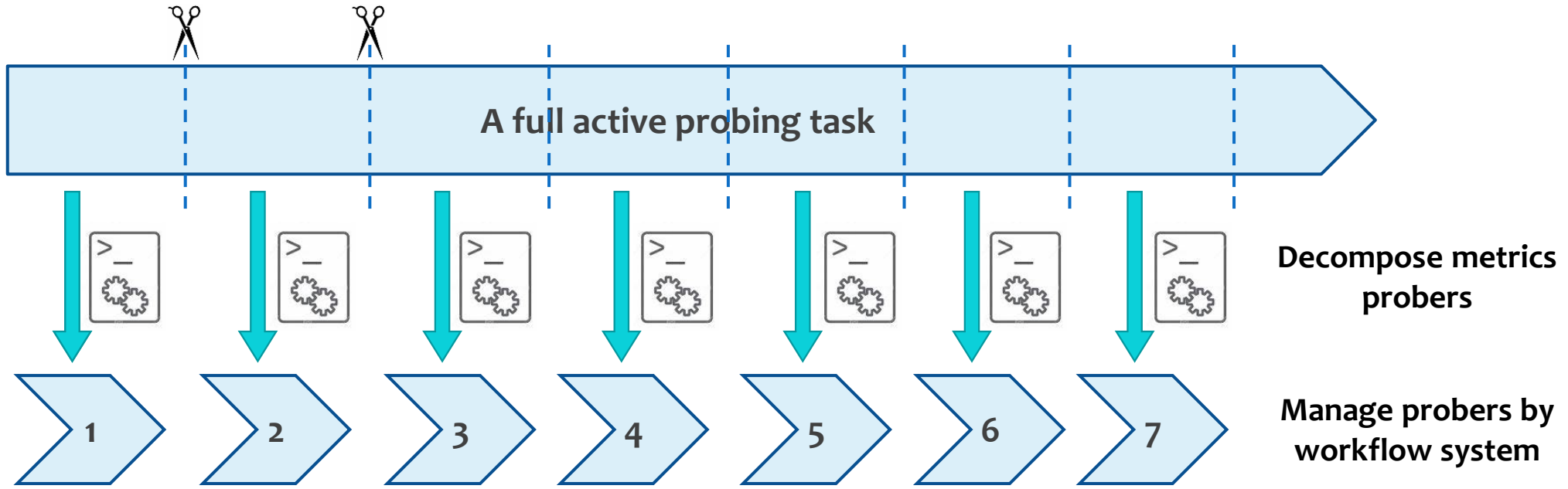
## TPC metrics (60+):

- Remote file listing, file uploading, file downloading, file deleting,
- Disk and Tape sites TPC transfer matrix tests,
- Large file transfer speed tests.

# Workflow-based Active Probing

**We choose workflow system to manage the scheduled probing scripts.**

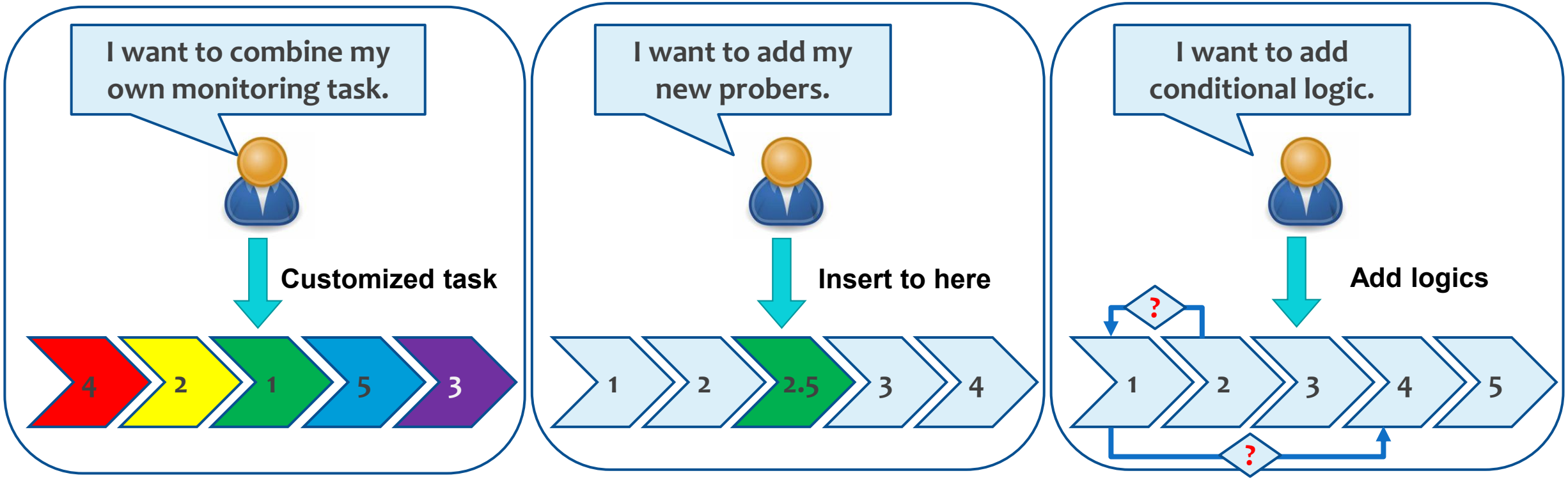
- All metrics for active probing can **be decomposed** into corresponding scripts.
- Each prober is packaged as **independent task component** in workflow system.



# Customized Monitoring Task

**As we are using work flow system, we allowed authorized user and administrators to:**

- Freely combine prober components.
- Develop their own prober components.
- Add conditional logic to workflows for advanced monitoring needs.
- And more…



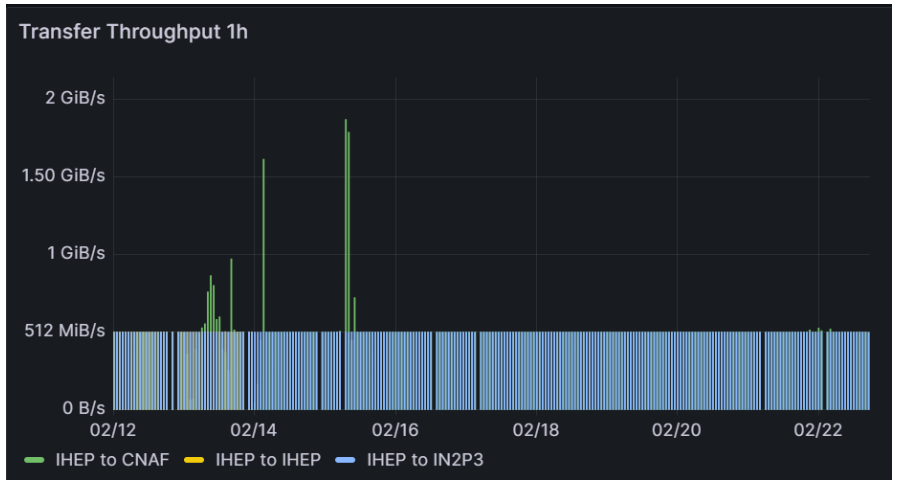
# Active Prober: JUNO Data Challenges

## JUNO will begin data taking in July 2025.

- 3 time data challenges were conducted before data taking .
- Active probing was **used in 2nd, 3rd data challenges** and their **pre-challenges**.

## Data Challenge scripts are designed to be compatible to workflow system.

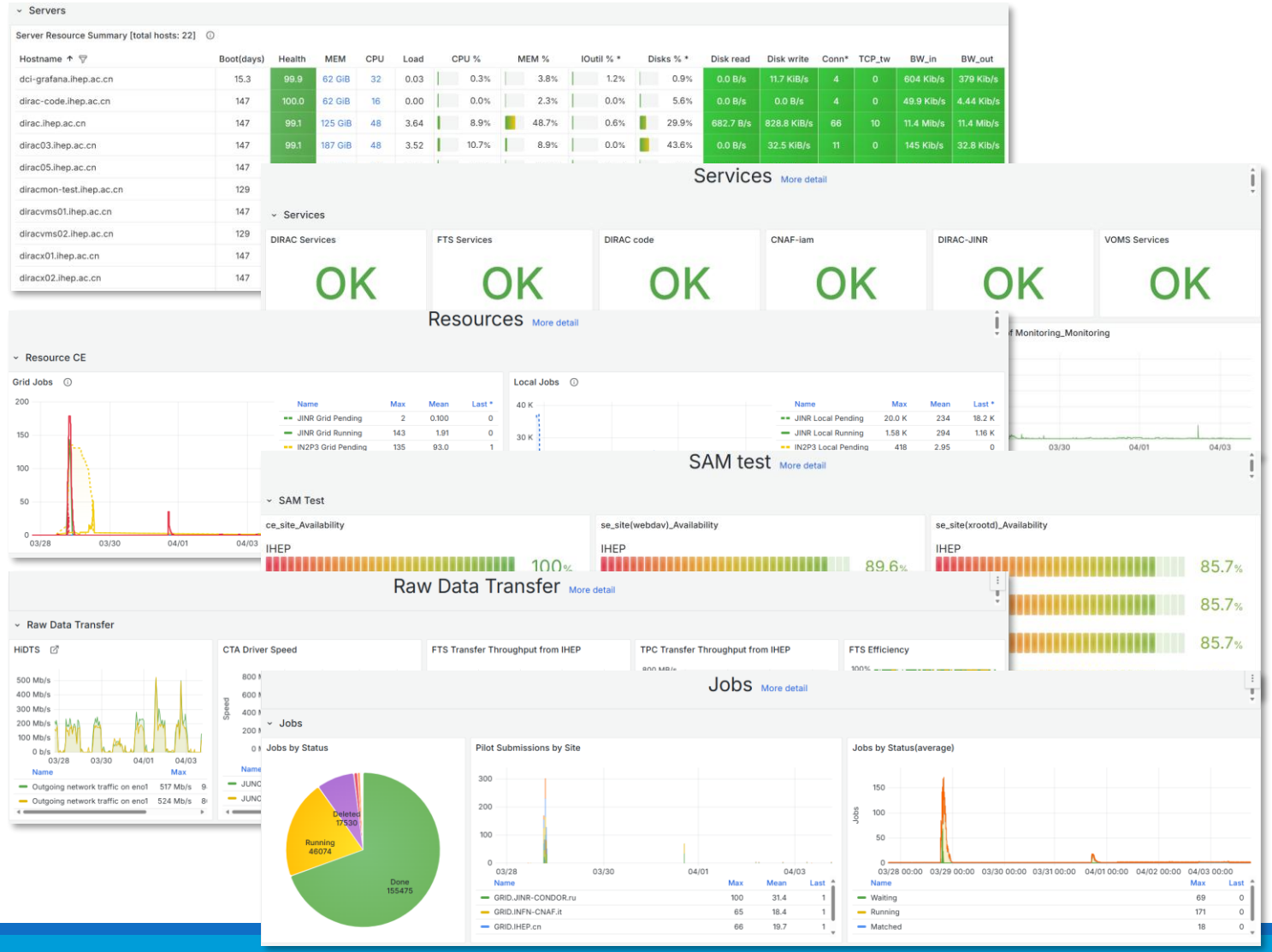
- Configurable expected transfer load.
- Workflow-triggerable design with scheduling capability.
- Transfer overload alert design.





Transfer throughput and efficiency probing in 2nd JUNO data challenges.

# Visualization: Grafana




https://dci-Grafana.ihep.ac.cn

**Already have 7 main dashboards with 400+ metrics.**

- ✓ Machine status
- ✓ Service status
- ✓ Resource accounting
- ✓ SAM test
- ✓ Data transfer status
- ✓ Grid job accounting
- ➢ More dashboards are adding…

# Alerting and Site Report

## Grafana alerting module is used for monitoring alerting.

## Alerted metrics:

- **Machine status:**
  - CPU usage rate, memory rate, disk I/O rate.
- **Site status:**
  - Disk and tape storage usage rate, site availability.
- **Transfer service status:**
  - FTS3 transfer efficiency, TPC performance transfer speed.

## Site Report:

- **A dashboard with sites usage account is presented for each site admins every 2 weeks.**

# Future Plan

## Extending metrics based on experiment needs:

- Services components fine-grained monitoring.
- Site availability metrics

## Integrating to other systems in JUNO experiment:

- Production system monitoring.
- Raw data taking monitoring.

## Extending the application to more experiments with distributed computing system:

- HERD, CEPC, etc.

## Optimizing monitoring architecture:

- Move to latest version of ElasticSearch.

# Summary

We constructed a monitoring system for JUNO experiment from zero.

The present monitoring dashboards encompasses basic service monitoring, active site status probing, transfer status testing.

To make our system more extendable and easy to be integrated to other experiment system, we introduced a workflow-based probing architecture.

Active probing monitoring allows our monitoring system manage system tests.

Our monitoring system has successfully enabled experiments to acquire required test results in certain applications, e.g Data Challenge.

Thanks for you attention!

# Some Details of Workflow

## Workflow system we use:

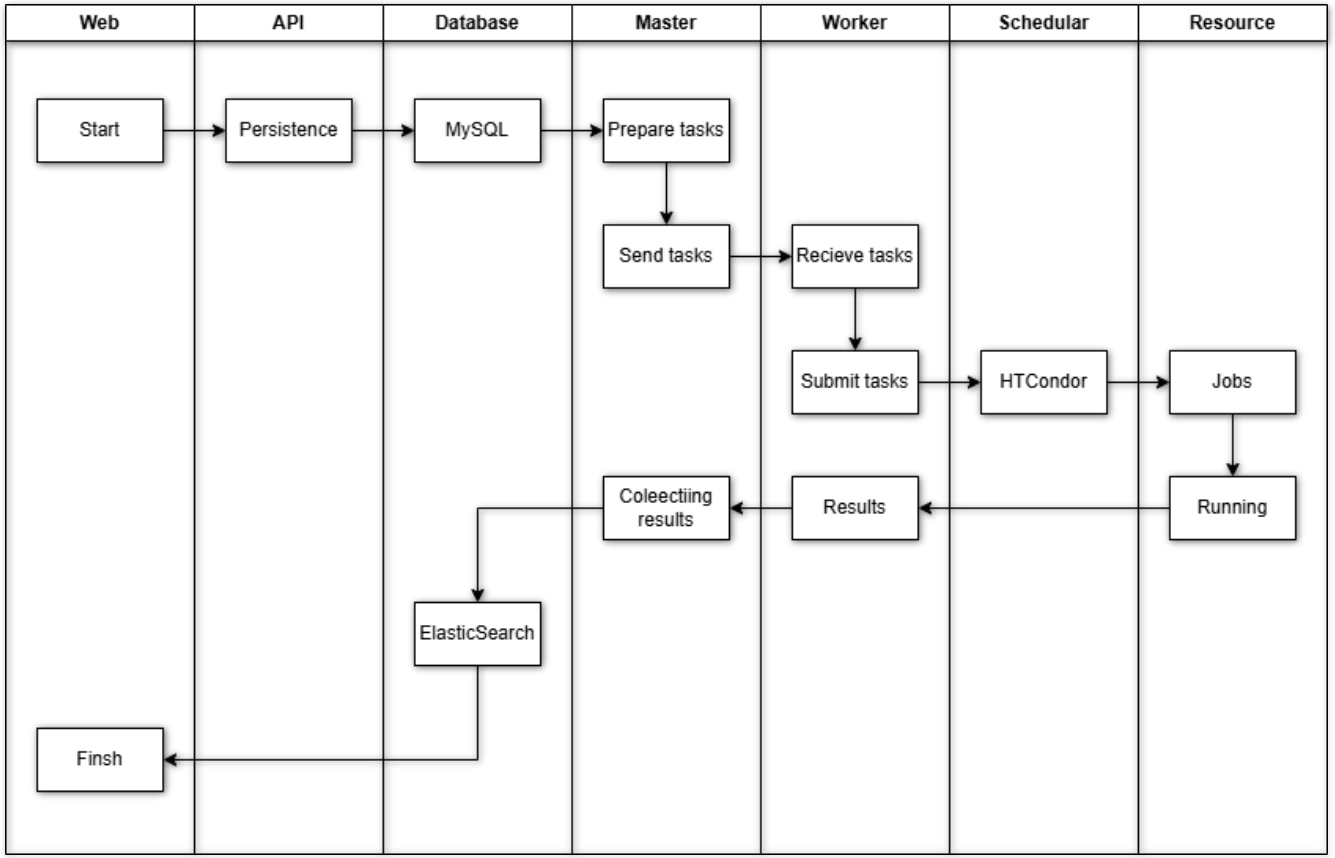
DolphinScheduler

## User permission management:

- IHEP SSO for user authentication.
- New user is automatically registered.

## MySQL database to store:

- User lists and permission lists.
- User workflows;
- Tasks components;
- Task queues;
- Resources;



# Running Probers on…?

**By default, all task should be running in workflow server, but:**

- Some metric probers can only be collecteded on site (e.g. CE site).
- Some probers occupy lots of resources (e.g. TPC performance test).

**Solution:**

- We **replaced the workflow worker resources** by HTCondor jobs or Kubernetes tasks with third party resources.