



JUNO Experiment

- The **Jiangmen Underground Neutrino Observatory**[1], a reactor antineutrino detector, is currently operating in Guangdong, China.
- JUNO detects antineutrinos emitted by 8 nuclear reactors located at 52.5 km away.

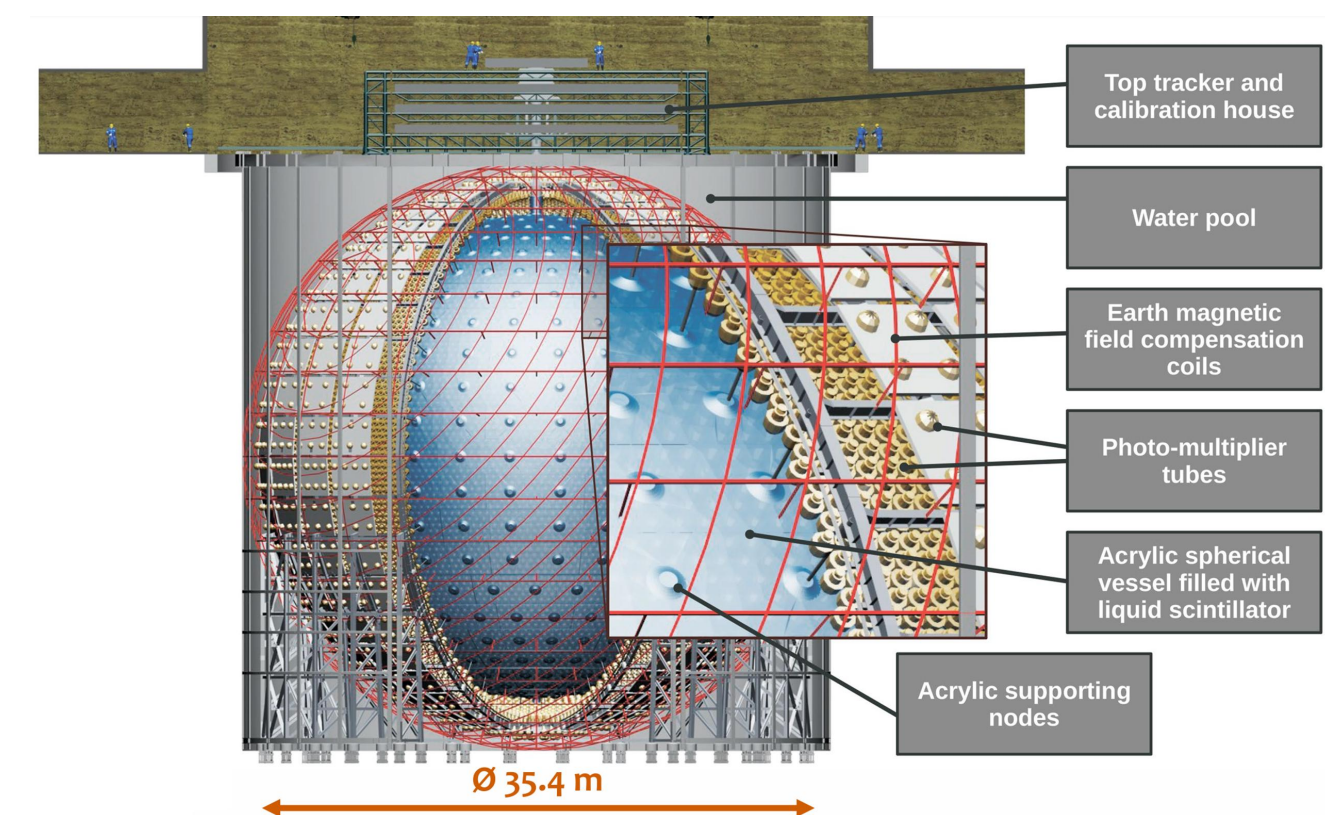
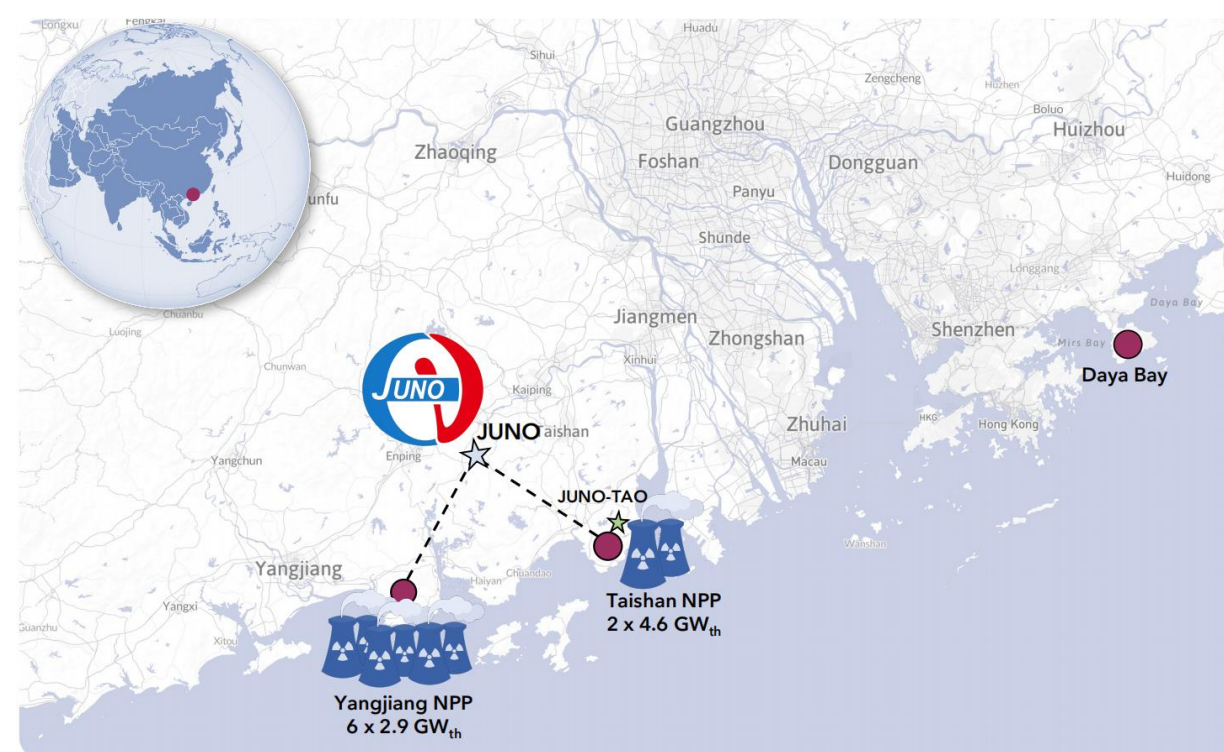


Fig 1: JUNO geographical location map.

Fig 2: The structure of JUNO detector[2].

The scientific goals of JUNO:

- **Neutrino mass ordering (NMO)** with 3σ in ~ 7 years of data-taking.
- Precision measurement of neutrino oscillation parameters.
- Measurements of atmospheric neutrinos, geoneutrino flux, and solar neutrino flux.
- Detection of supernova neutrinos.
- Other physics, such as nucleon decays, sterile neutrinos, and dark matter.

Data Processing Workflow

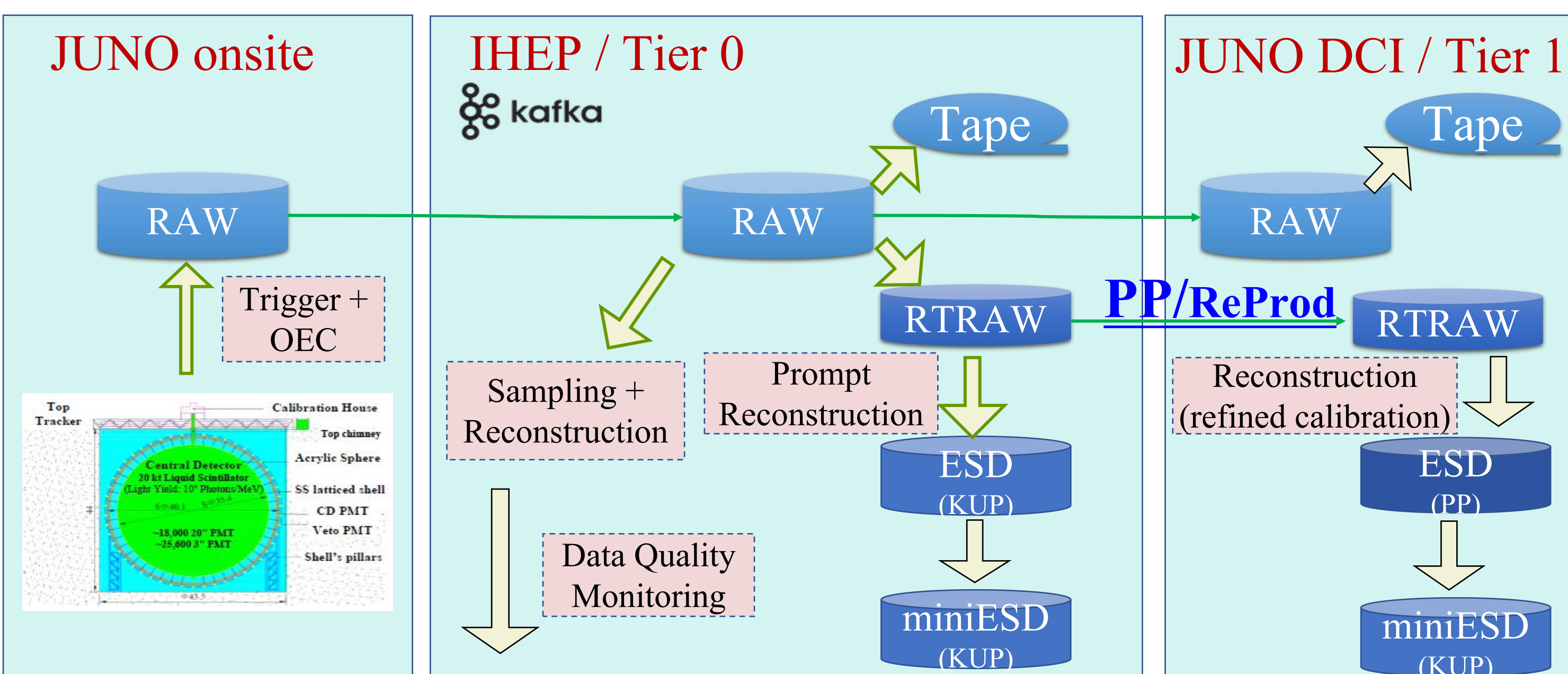


Fig 3: Data processing workflow of JUNO[3].

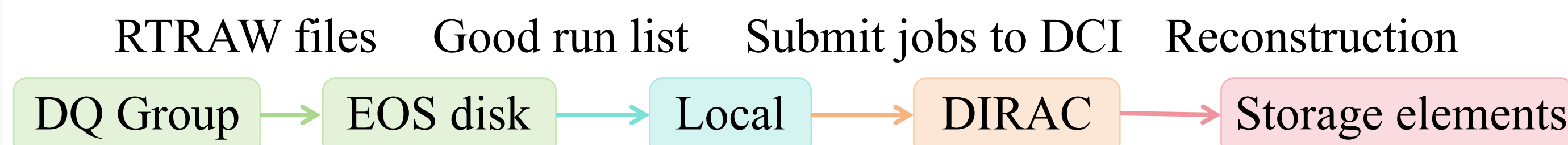
Data file format:

- **RAW**: Real detector data from the DAQ, stored in byte-stream format.
- **RTRAW**: ROOT-based raw data, including waveform and T/Q, trigger and OEC information, used for MC: MCParticle, SimHits, and SimTrack.
- **ESD/miniESD**: Event Summary Data (ESD / miniESD). ESD includes the calibrated T/Q, reconstructed vertex and track. miniESD includes compact analysis-oriented format.

➤ **Physics production (PP)**: Refer to data reprocessing using refined calibration constants and validated reconstruction algorithms, providing the baseline input for physics analysis.

JUNO data production

1. The workflow of data production with DCI:



- 1.1 RTRAW files provided by data quality (DQ) group are stored on the EOS disk.
- 1.2 According to the Good Run List, RTRAW files are used as input.
- 1.3 Generate transformation locally and submit jobs to DCI system.
- 1.4 The jobs are monitored and managed through DIRAC.
- 1.5 The reconstructed ESD files are stored on storage elements.

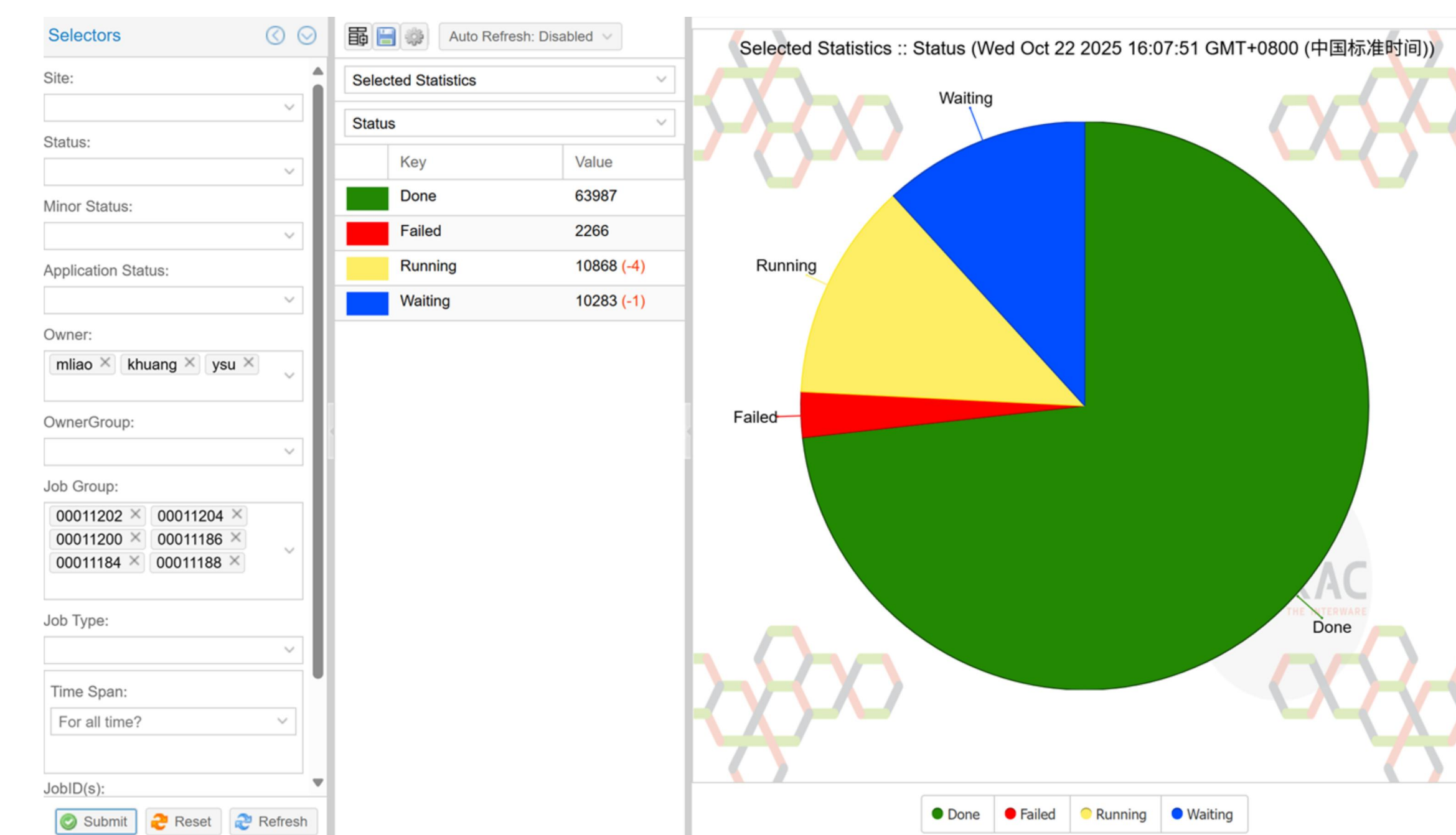


Fig 4: DIRAC web interface for job status monitoring.

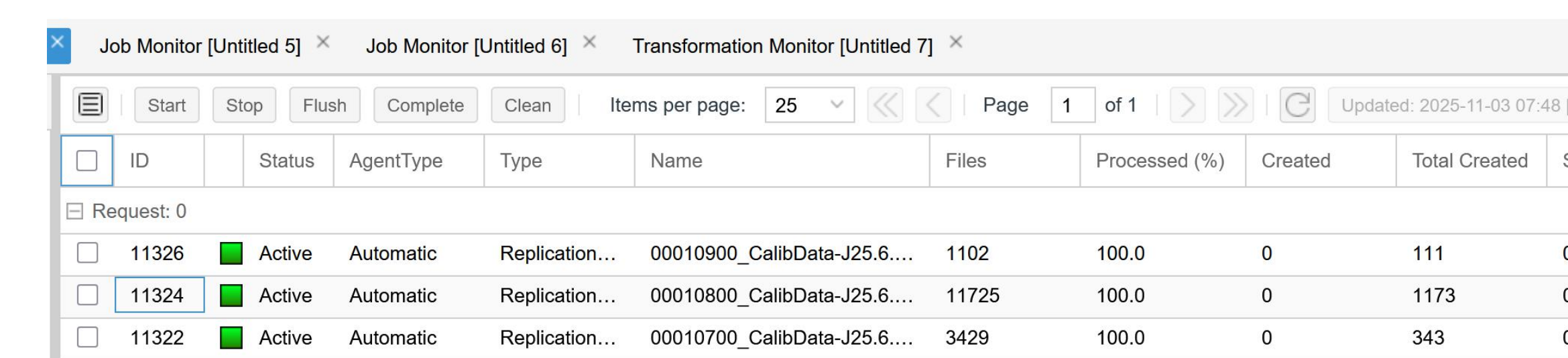


Fig 5: DIRAC web interface for replication monitoring.

2. Dynamic Reconstruction Steering

- 3 independent reconstruction algorithms: OMILREC, VTREP, JVertex.
- Refined reconstruction algorithms are CPU-intensive for low-energy events. Dynamic steering is used to select appropriate algorithms based on the event type and energy.

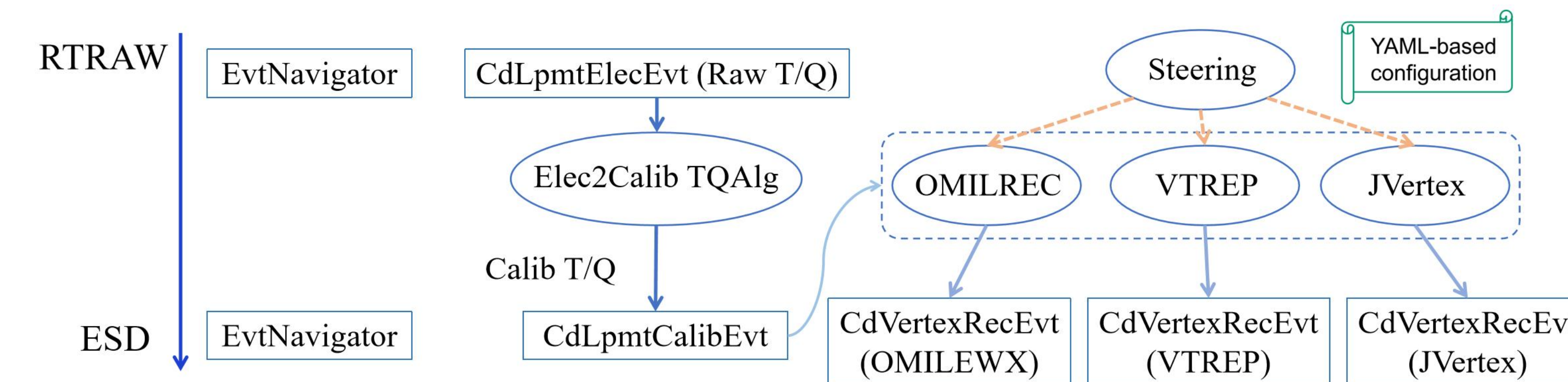


Fig 6: PMT calibration and event reconstruction.

3. Issues and challenges in production process

- A small number of job failures still remain:
 - ✓ check the reasons and reschedule these jobs.
- Accessing ESD files for many analyses puts a high load on the EOS storage system.
 - ✓ **Reduce data volume**: ESD -> miniESD.
 - ✓ **Limit heavy access to EOS**: mini-ESD files are available to all JUNO users and ESD files are only available to limited users.
 - ✓ **Improve parallel access for miniESD**: replicating mini-ESD files in different storage system.

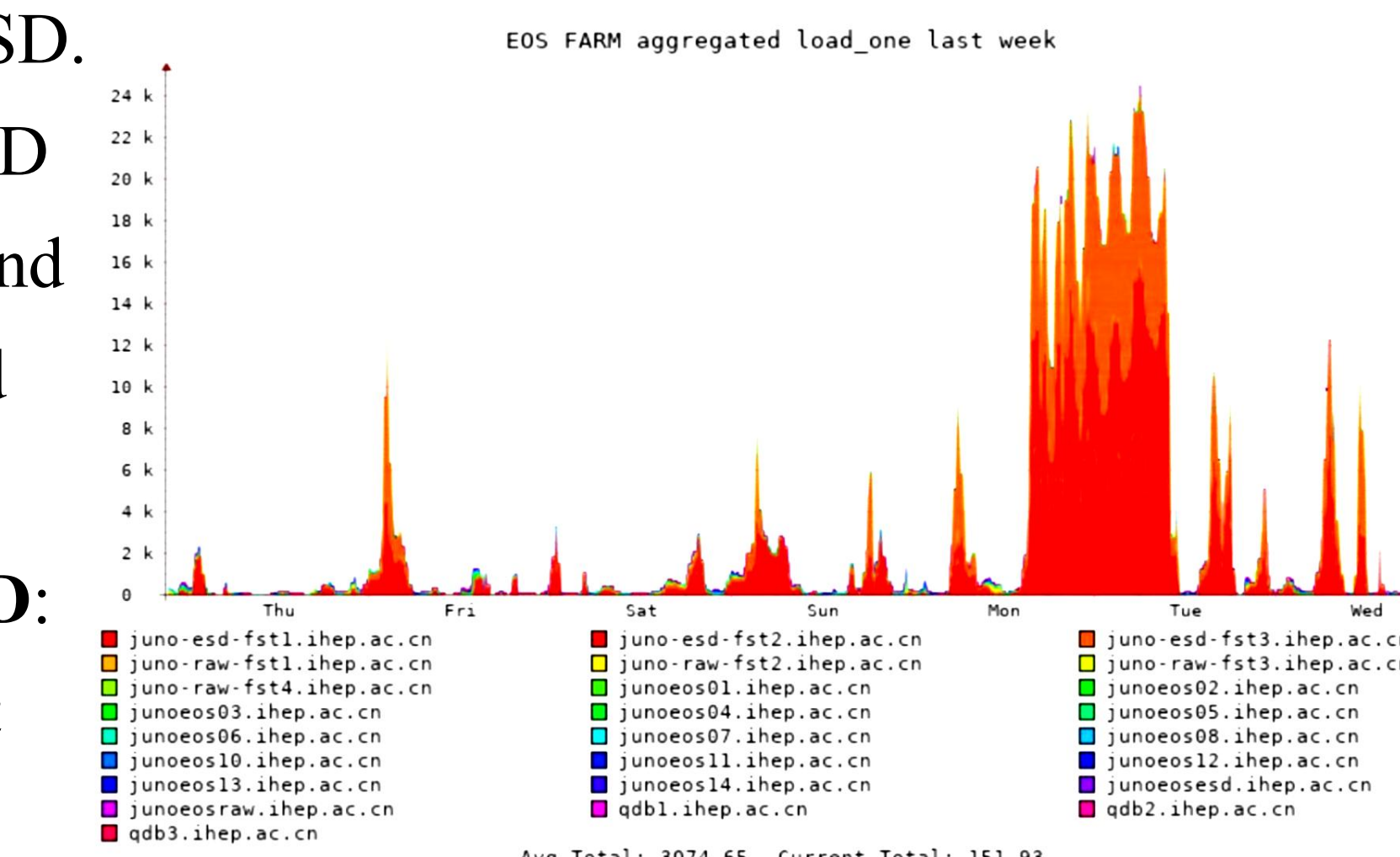


Fig 7: High load on the EOS.

Data Production cases

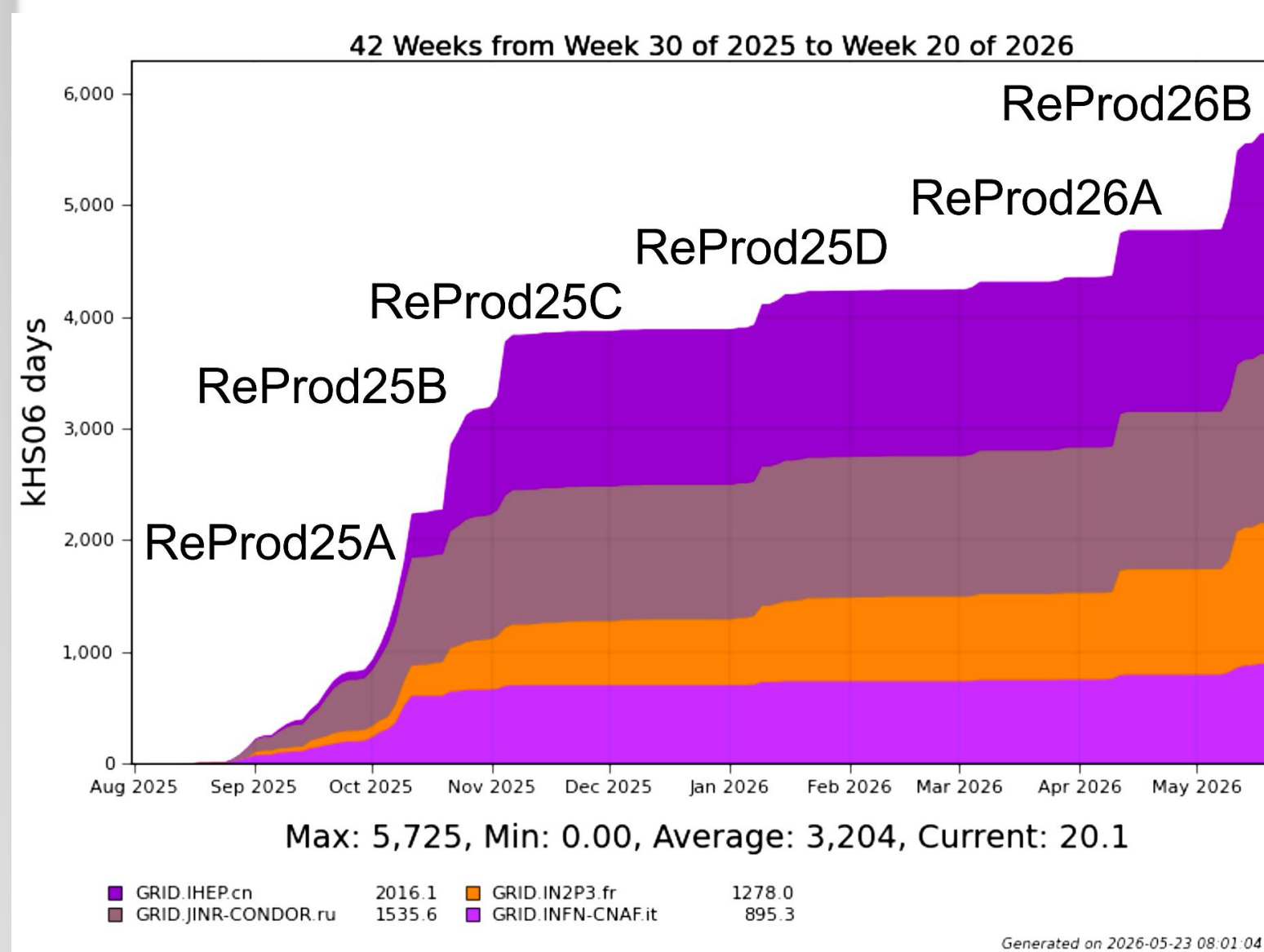


Fig 8: Normalized CPU used by Site.

➤ **Six ReProd campaigns have been carried out since physics data taking began.**

- Datasets from ReProd25C, in which about 477k jobs were processed with an estimated CPU time of 0.55 CPU hours/job for DCI running, have been used for the first oscillation results of JUNO[4].

Summary

- The goal of data production is the reconstruction from RTRAW to ESD. The work includes dynamic reconstruction steering, job submission and monitoring, checking and addressing of failed jobs, and challenging to high load.
- Six data production campaigns have been completed. And ReProd25C data has been successfully applied to the first results of JUNO.
- A complete tutorial for the entire production workflow has been written and will be used for subsequent data production campaigns.

[1] JUNO physics and detector, Prog.Part.Nucl.Phys. 123 (2022) 103927.

[2] Modern Software Development for JUNO offline software, EPJ Web Conf. 295 (2024) 05015.

[3] Keep-up Production in JUNO's Offline Data Processing, EPJ Web Conf. 337 (2025) 01176.

[4] First measurement of reactor neutrino oscillations at JUNO, Nature volume 654, pages 343-348 (2026).