Lightweight site federation for CMS support

A. Delgado Peris on behalf of the CMS collaboration

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1 PIC, UAB, Bellaterra (Barcelona), Spain
2 IFAE, UAB, Bellaterra (Barcelona), Spain
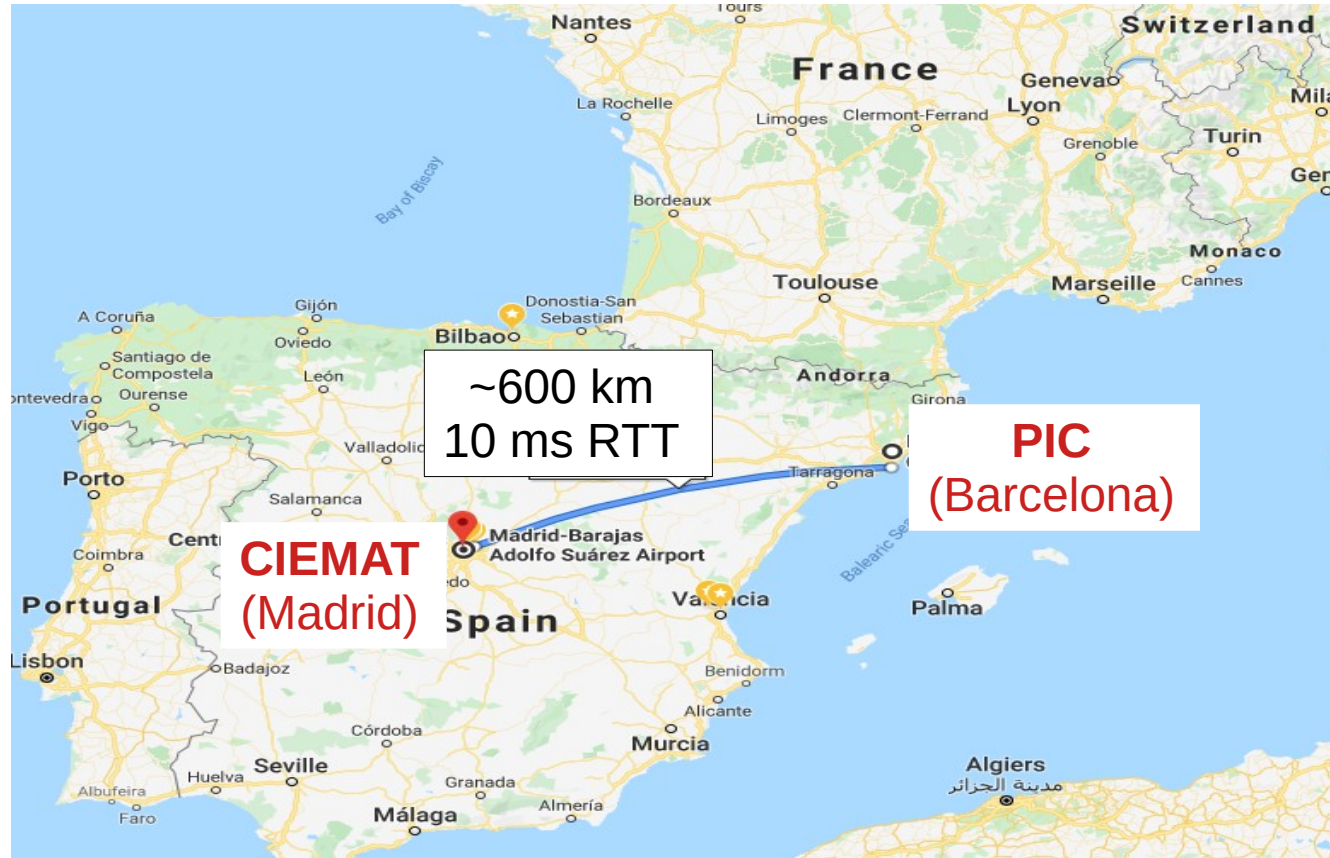3 CIEMAT, Madrid, Spain

Outline

- Motivation and problem outline

- Implemented solution

- Overall results evaluation

- Results detailed view (*timewise*)

- Future work and conclusions

Federation of Computing Resources

- WLCG trend towards the federation of resources
    - Use resources/access data, of different sites, *transparently* (single access point)
    - Aim for higher simplicity, efficiency, flexibility, availability

- General solution for resource federation between independent and autonomous sites may prove difficult

- This work shows a simpler solution
    - Two close sites, shared CE/batch, one experiment (CMS)

The case of PIC and CIEMAT

~600 km
10 ms RTT

PIC
(Barcelona)

CIEMAT
(Madrid)

The case of PIC and CIEMAT

- Relatively nearby locations

  – Good network interconnection (to be improved, midterm future)

- Shared CE/batch and SE/data-access technology

  – HTCondor and dCache/xrootd

- Long-standing close collaboration of both site teams

  – CMS Tier-1 and Tier-2 in the Spanish region
 – CIEMAT provides 50% of PIC funding

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Job handling: HTCondor

- Take advantage of both sites using HTCondor as technology for CE and batch system

  – Many possible federation mechanisms

- HTCondor's *job re-routing* chosen

  – Completely functional for our test case

  – Keep independent configurations for the sites

  – Don't open networks, don't share daemon passwords

- Still, open to reassessment

HTCondor: standard deployment

HTCondor: re-routing

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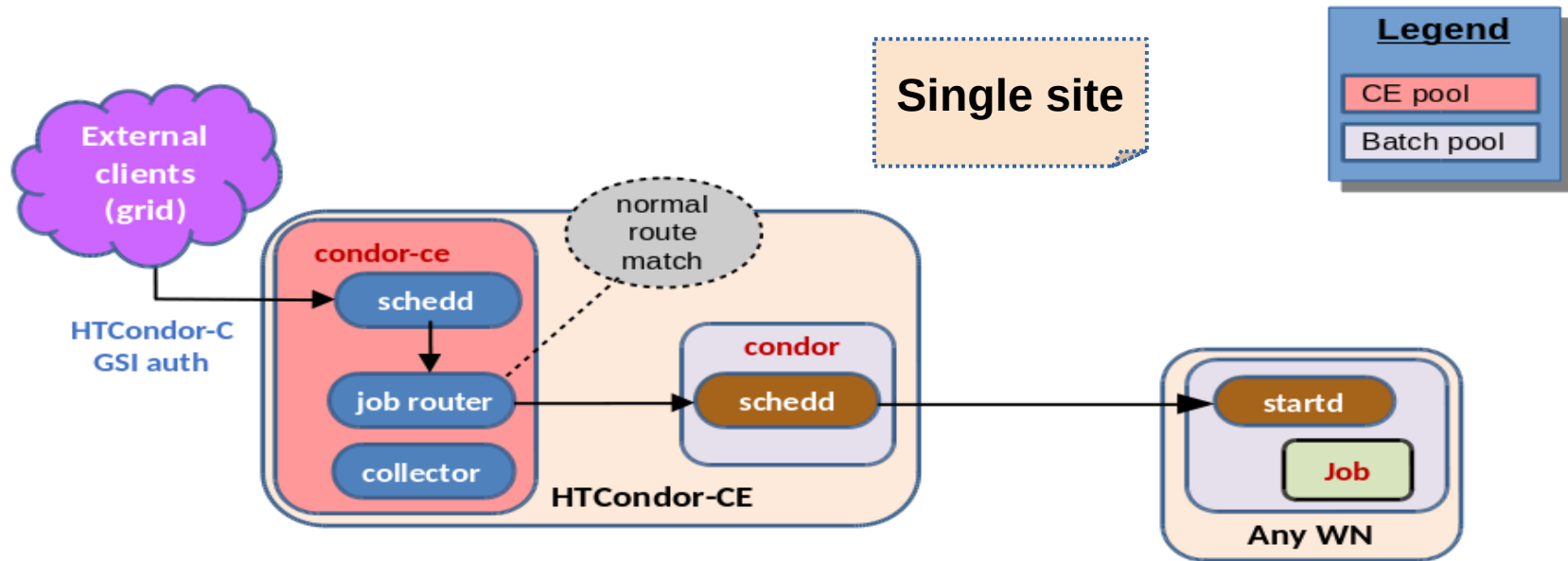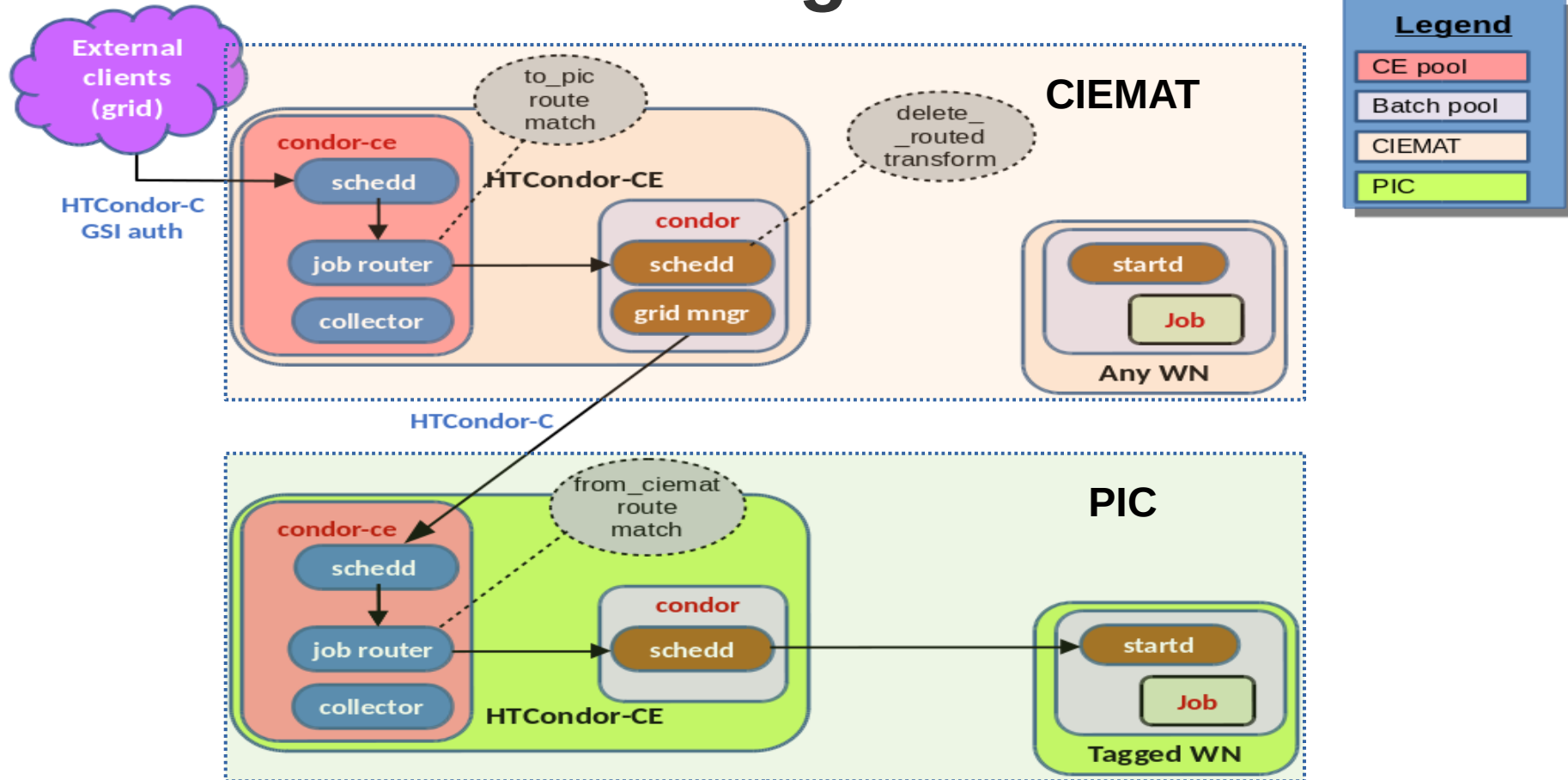
N. B.: we are re-routing *pilots*

- CMS uses a late-binding scheduling model
  - Pilot jobs are sent to sites (*that's all the batch sees*)
  - Real payload jobs are matched to already-running pilots

- So: a *meant-for-CIEMAT* pilot might end up running at a PIC's worker node (and vice versa)
  - And: a *meant-for-CIEMAT* payload job might be matched by a re-routed pilot running at PIC (and vice versa)

- All pilots are essentially the same
  - They may match *any type* of payload job

HTCondor re-routing pitfalls

- Unavailability of any of the two involved sites affects the ability to re-route pilots.
  - Recovery automatic
  - WNs usable by *normal* local jobs (no loss of resources)

- Found a (possible) bug (reported)
  - `AssertionError` on `GridManager` caused by a single job prevents processing of further jobs

- Need to delete the `routed` attribute
  - This is known, but need to be aware

Access to data: xrootd

- CMS xrootd federation: transparent location discovery and access of data

- Added a new layer to favor access to *regional* (PIC-CIEMAT) data (rather than *elsewhere*)
  - Only for *locally running CMS jobs*
  - Only go *regional* when *data not found locally*

- Makes use of CMS *Trivial File Catalog*
  - *Direct* entry points to local dCache door
 - *Fall-back* entry points to regional redirector
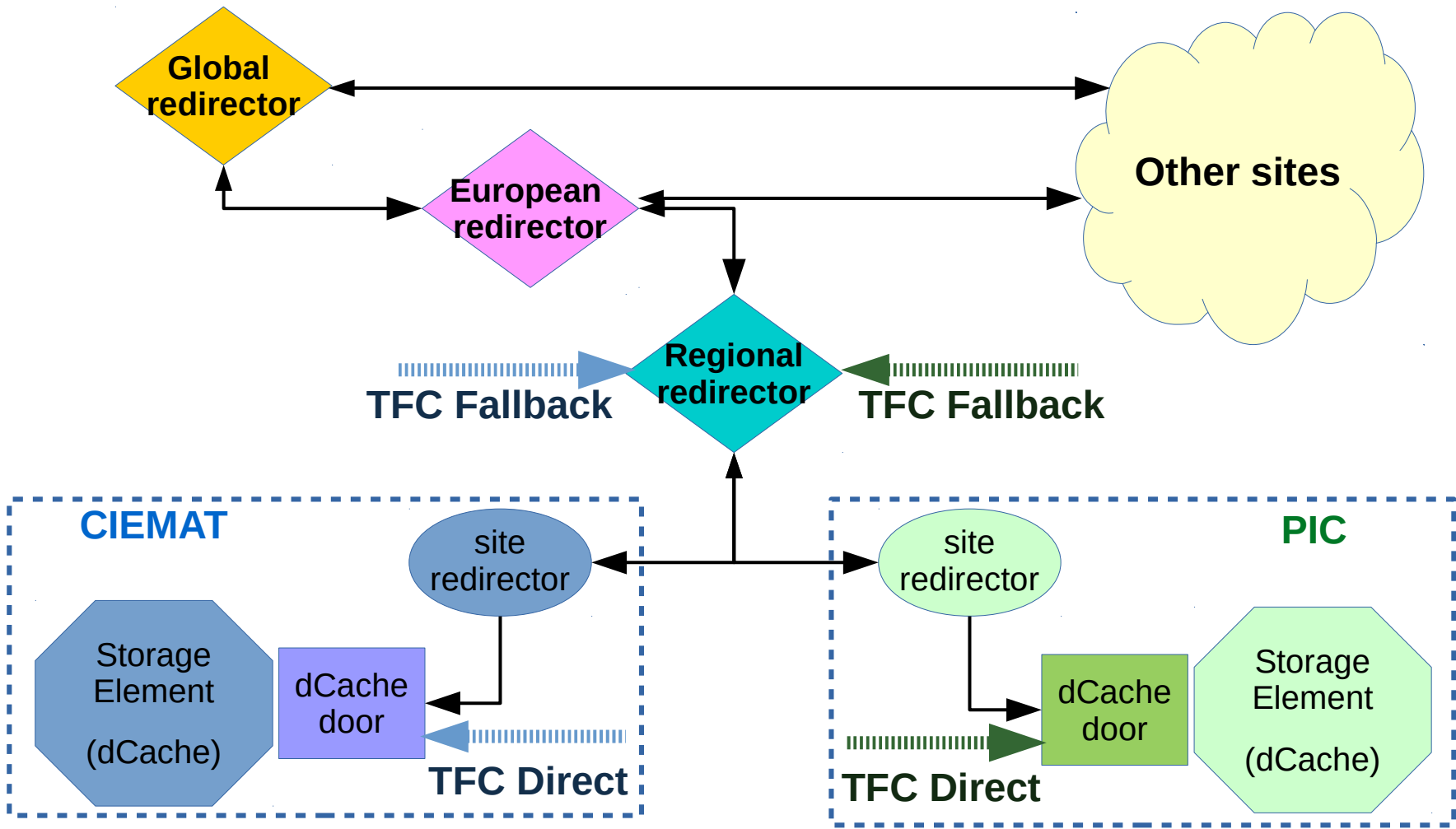
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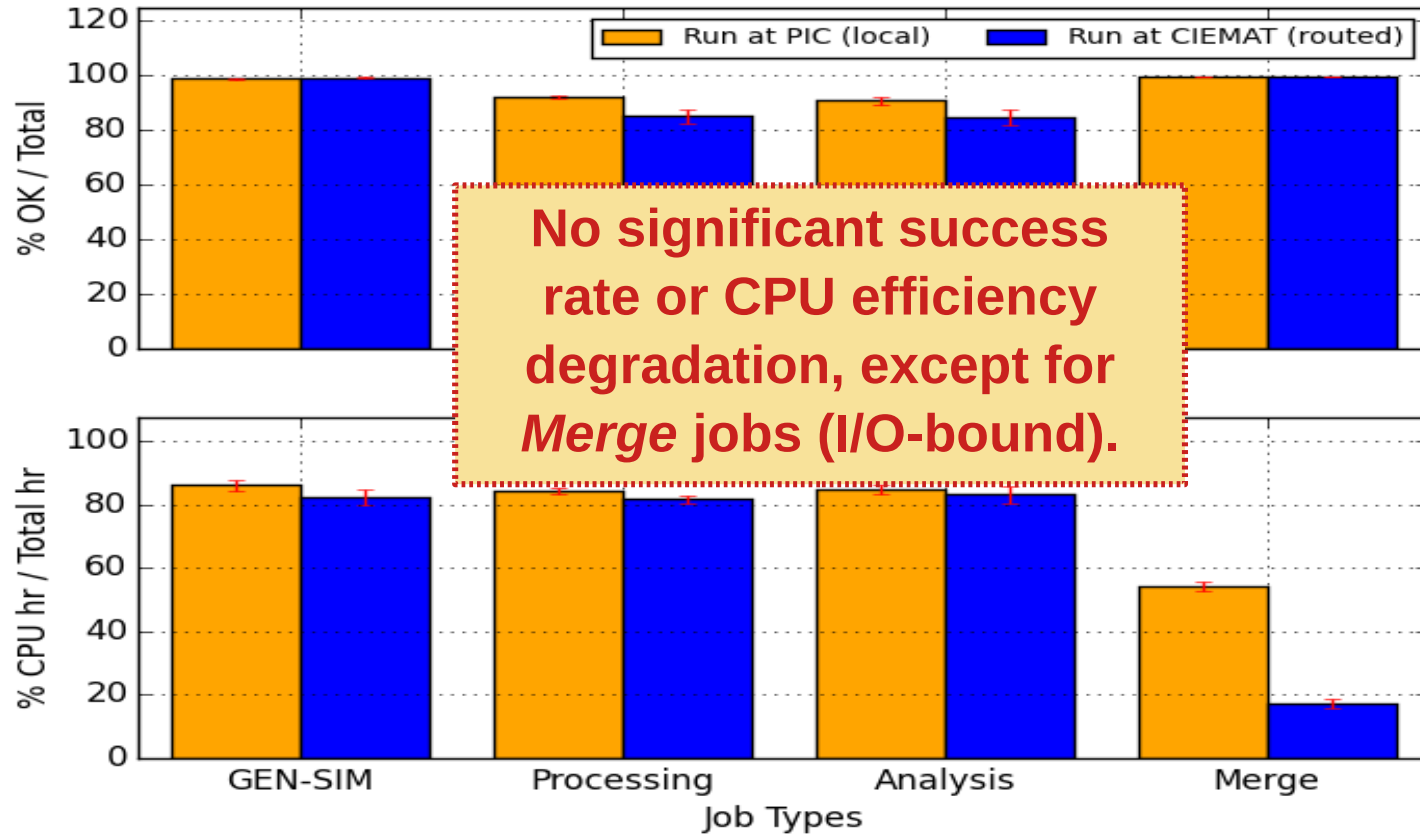
Rates by job type: jobs meant for PIC
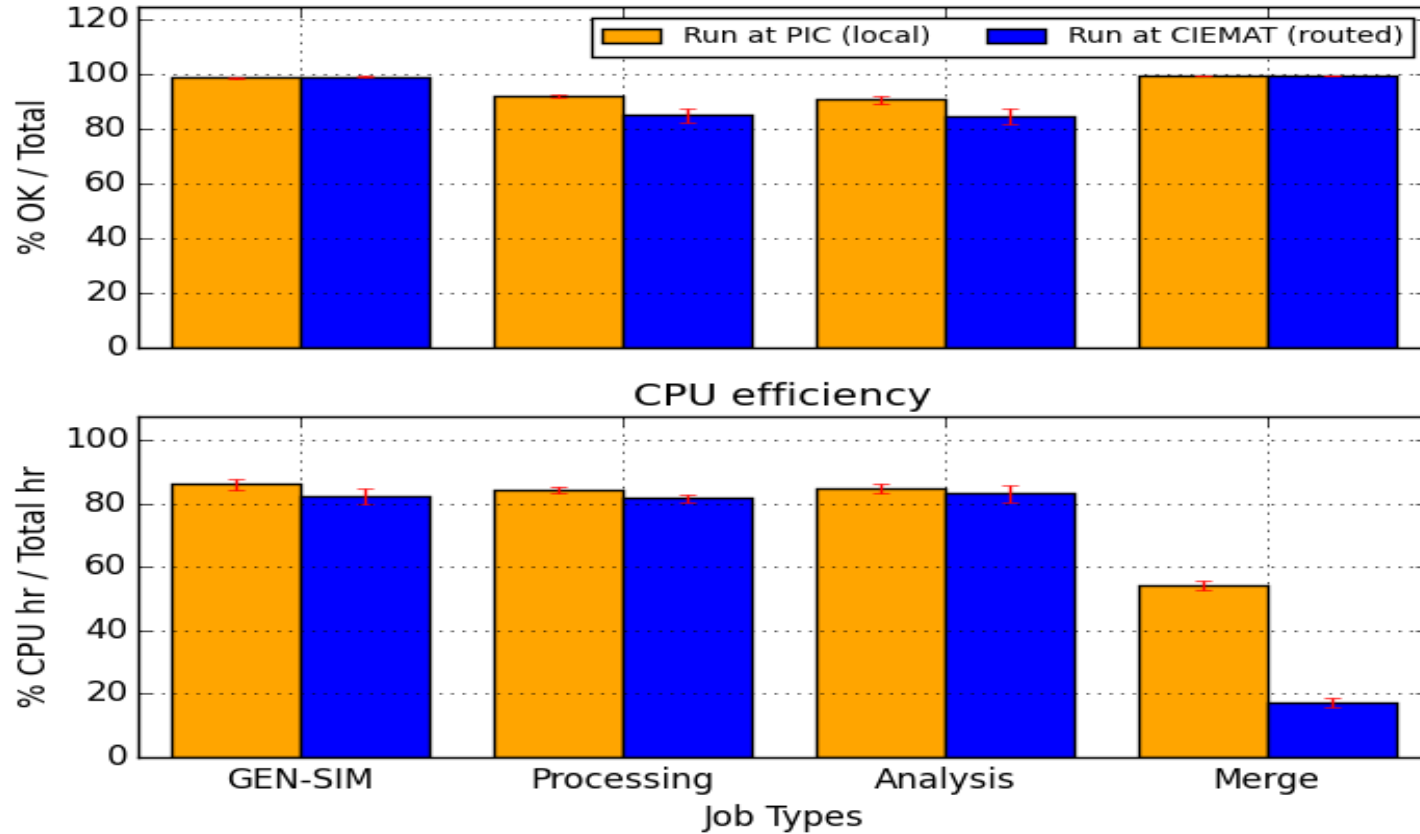
Re-routed

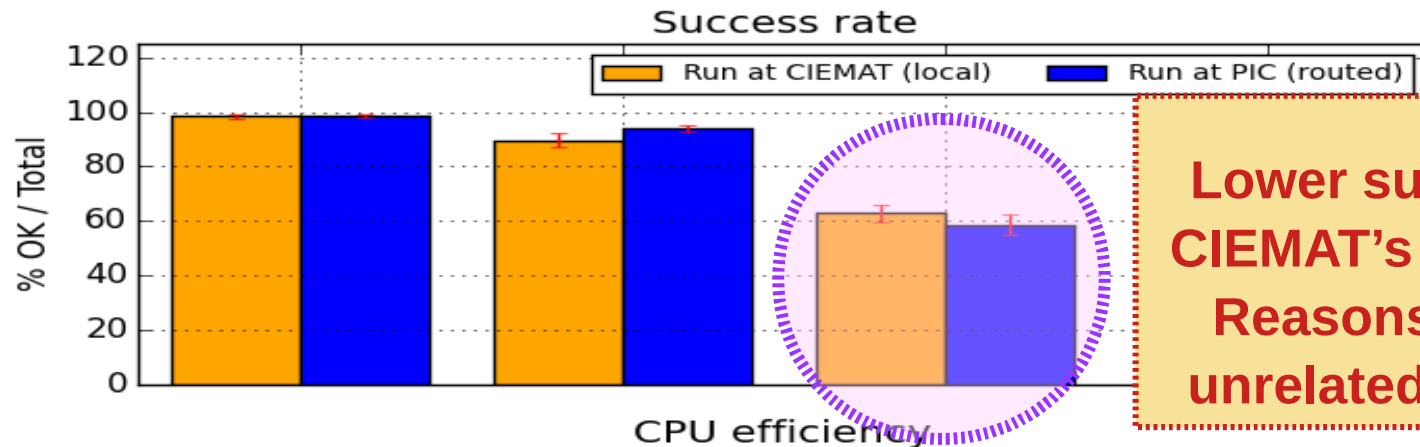10 dedicated 8-core pilot slots per site

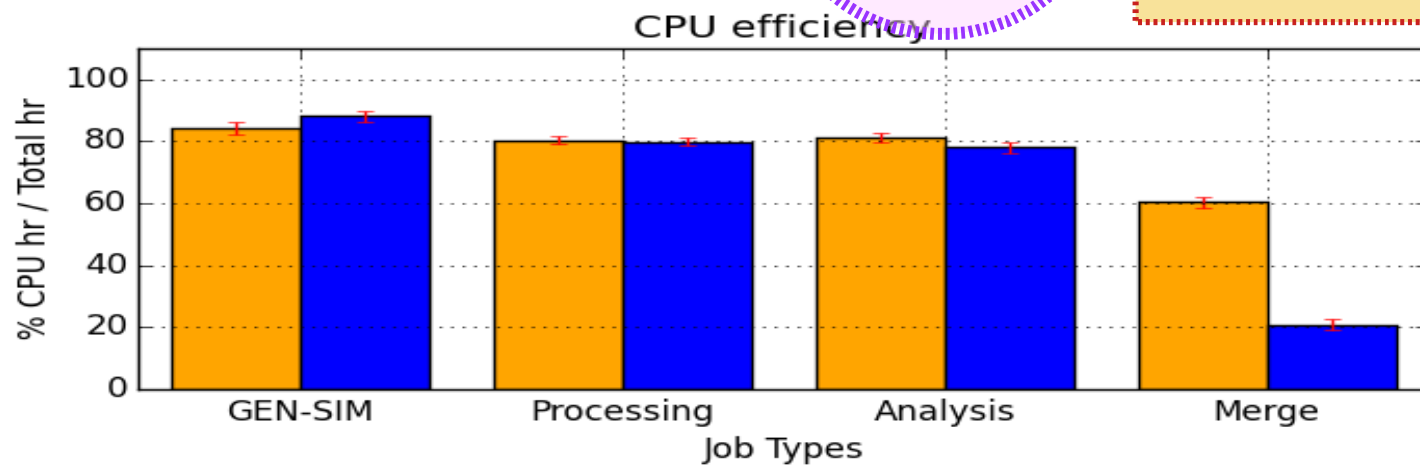(up to 80 payloads)

6 months

Rates by job type: jobs meant for PIC

No significant success rate or CPU efficiency degradation, except for *Merge* jobs (I/O-bound).

Rates by job type: jobs meant for CIEMAT

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Rates by job type: jobs meant for CIEMAT

Success rate

Legend: Run at CIEMAT (local) — orange; Run at PIC (routed) — blue
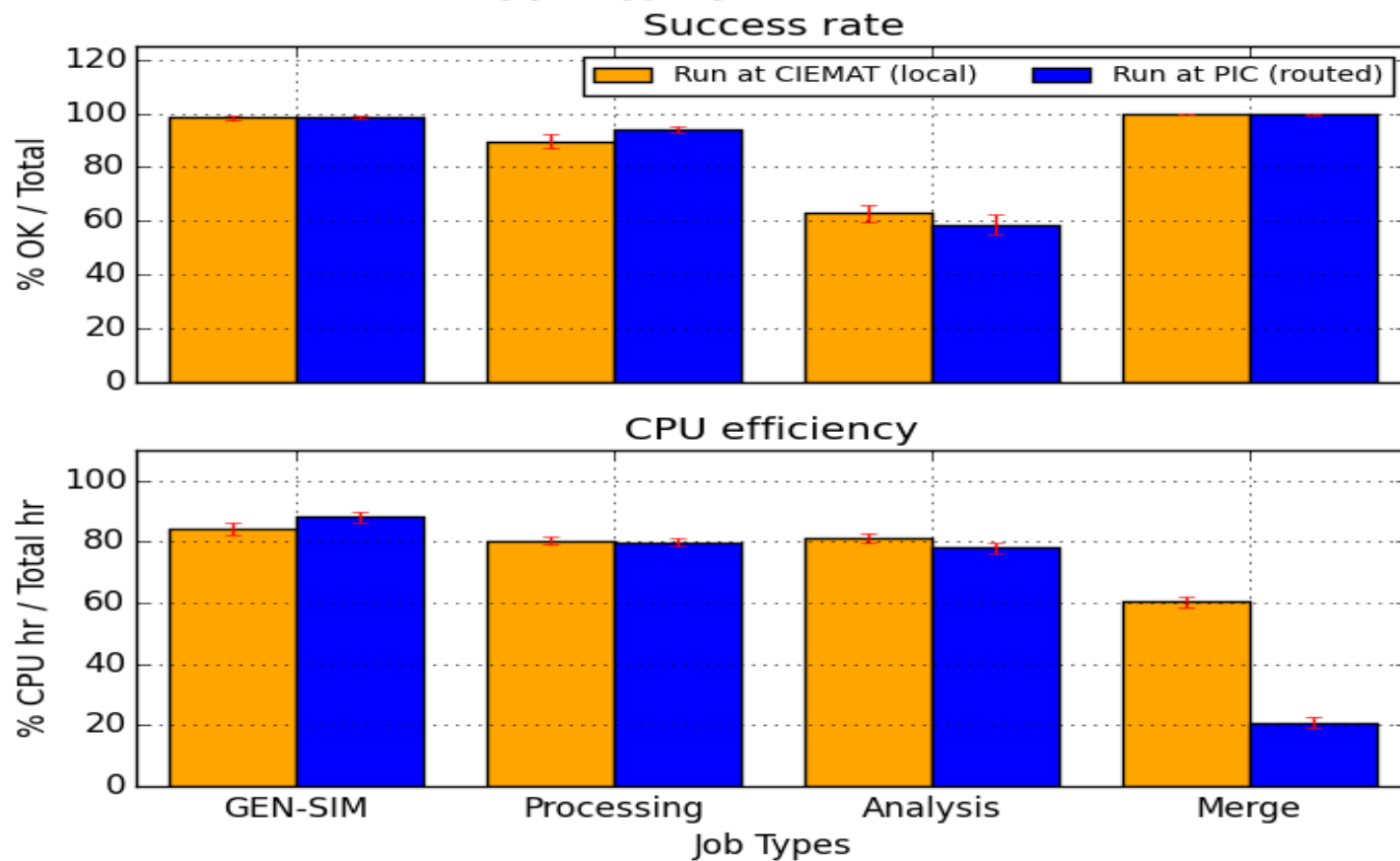
Lower success rate for CIEMAT's analysis jobs. Reasons unclear, but unrelated to re-routing.

CPU efficiency

Job Types: GEN-SIM, Processing, Analysis, Merge
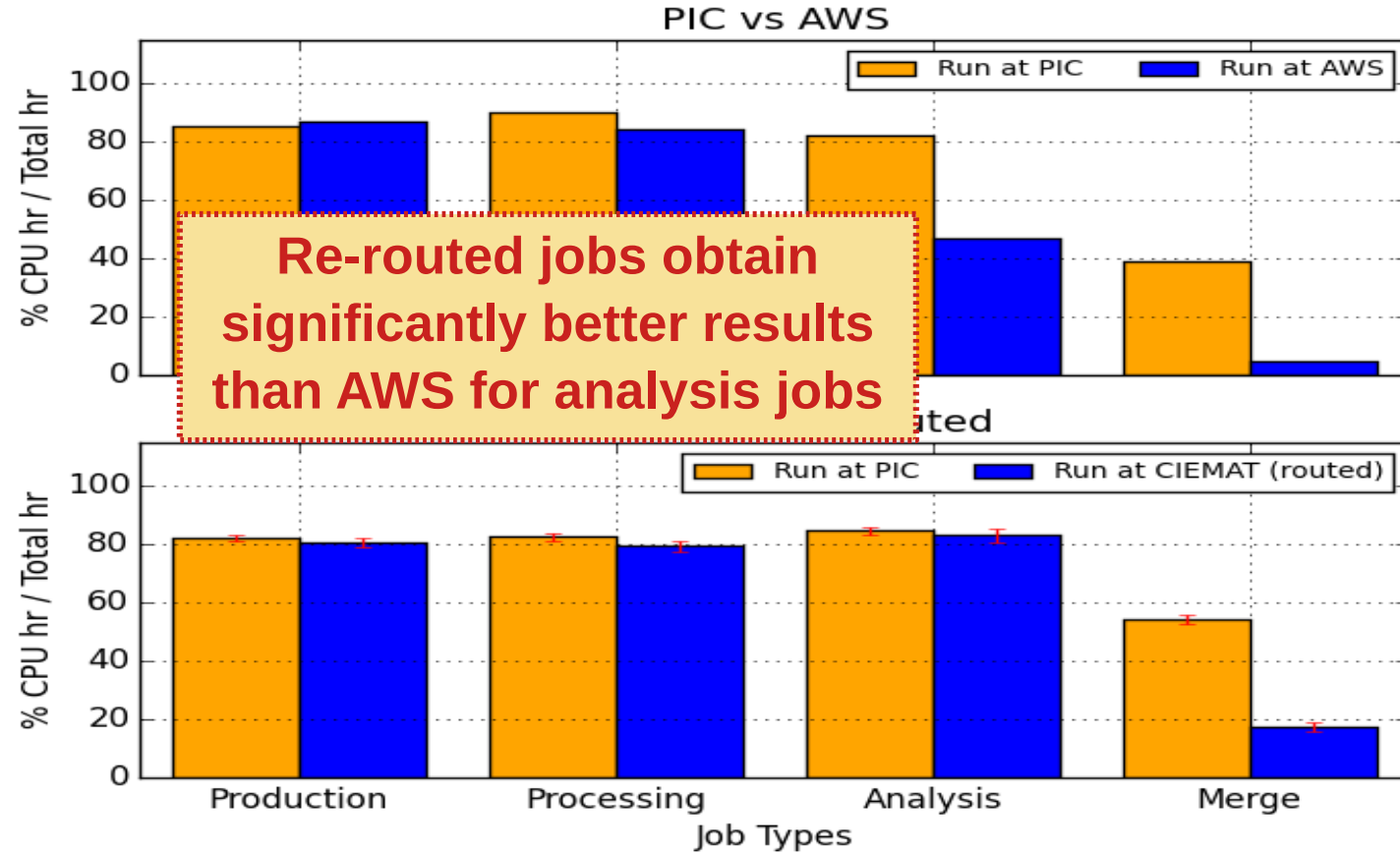
CPU efficiency by job type: PIC vs CIEMAT vs AWS
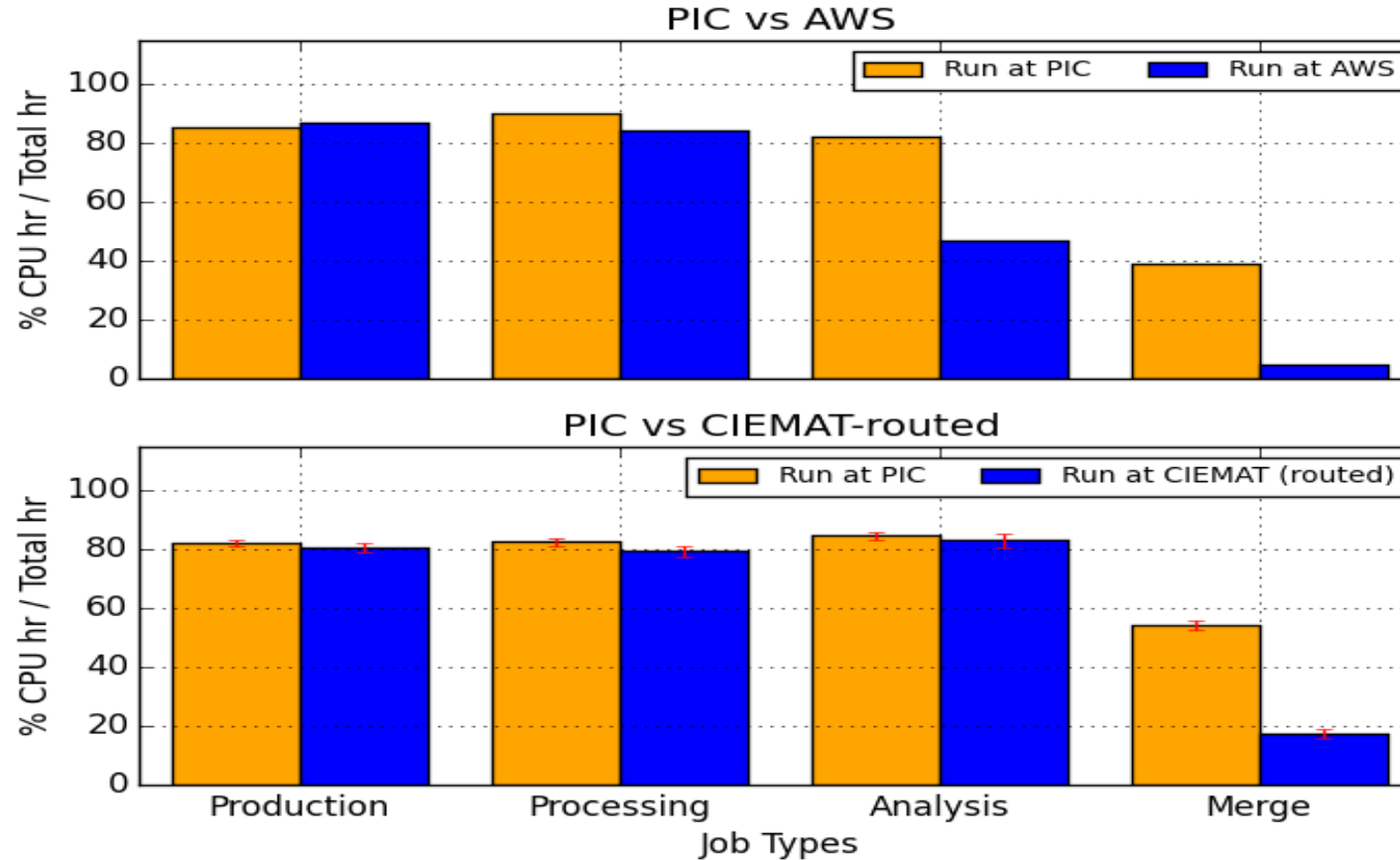
Compare

Elastic extension of PIC farm on Amazon AWS
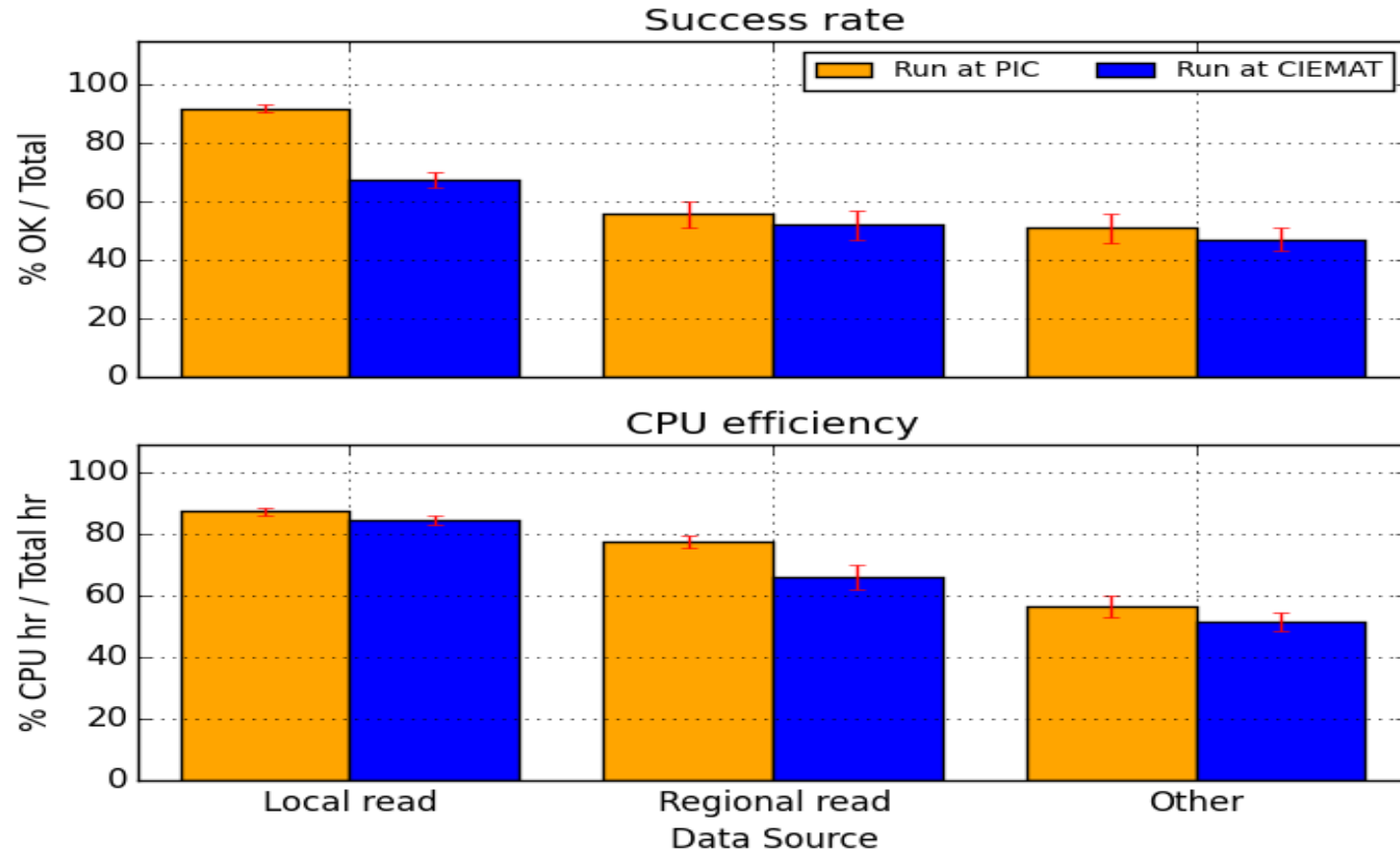
1-week test

Frankfurt center, 40 ms RTT

CPU efficiency by job type: PIC vs CIEMAT vs AWS

PIC vs AWS

Re-routed jobs obtain significantly better results than AWS for analysis jobs

CPU efficiency by job type: PIC vs CIEMAT vs AWS

PIC vs AWS

Re-routed jobs obtain significantly better results than AWS for analysis jobs

- **Lower RTT at CIEMAT (10 ms vs 40 ms)**
- **Jobs at CIEMAT find some input files locally, while jobs at AWS read every file remotely**
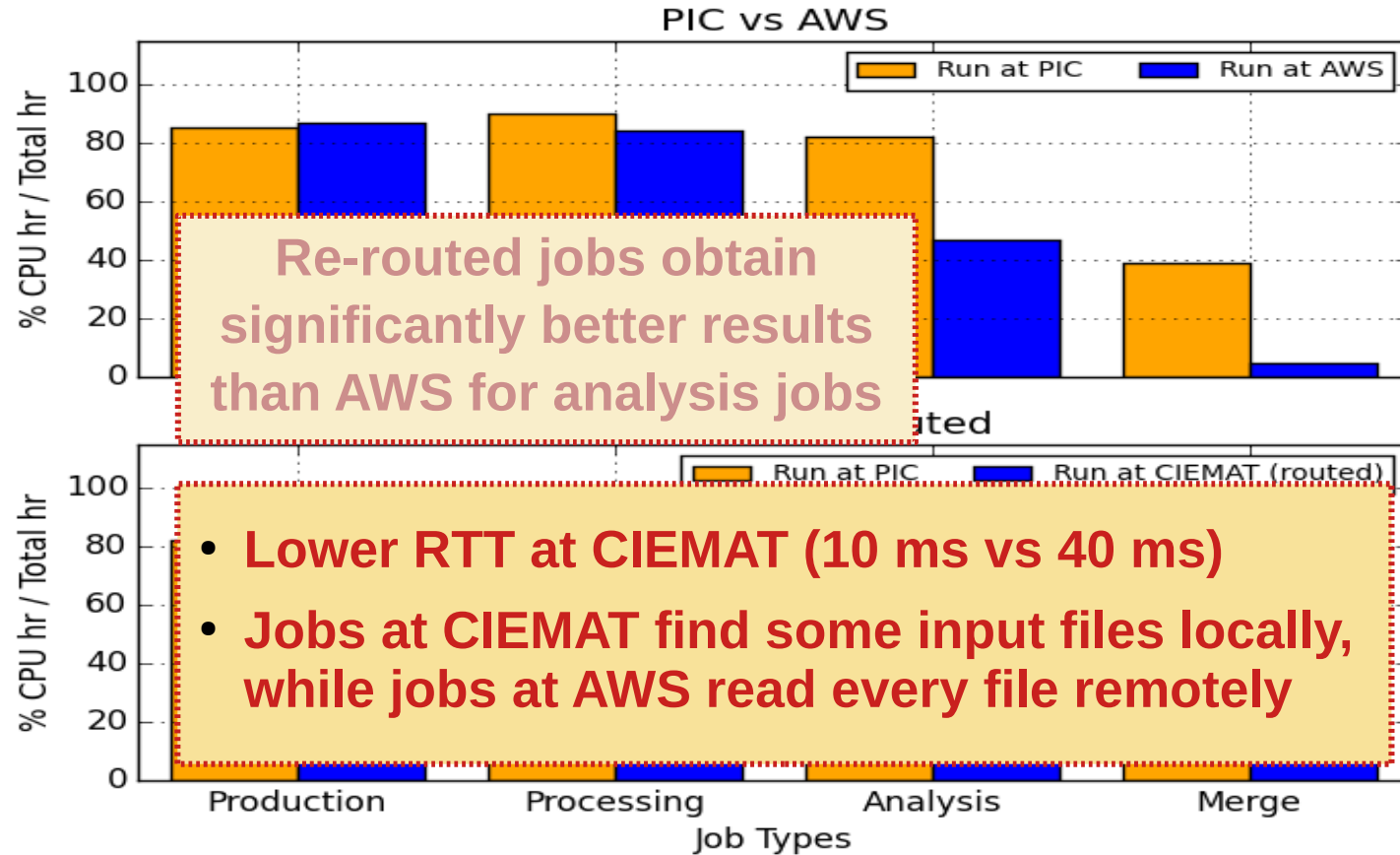
Rates by read origin for analysis jobs

Closer look

Where analysis jobs really read data from

Rates by read origin for analysis jobs
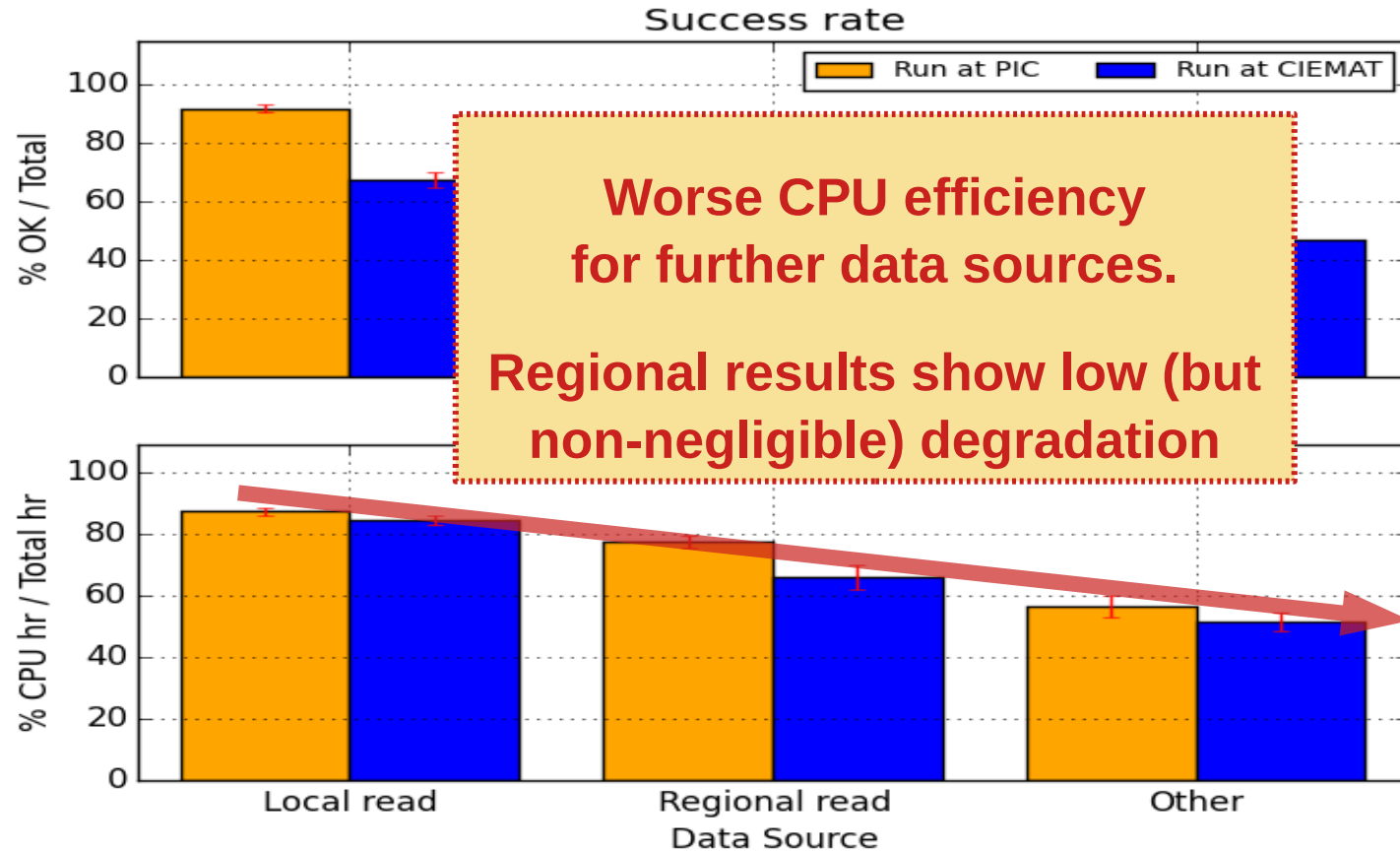
Success rate

Worse CPU efficiency
for further data sources.

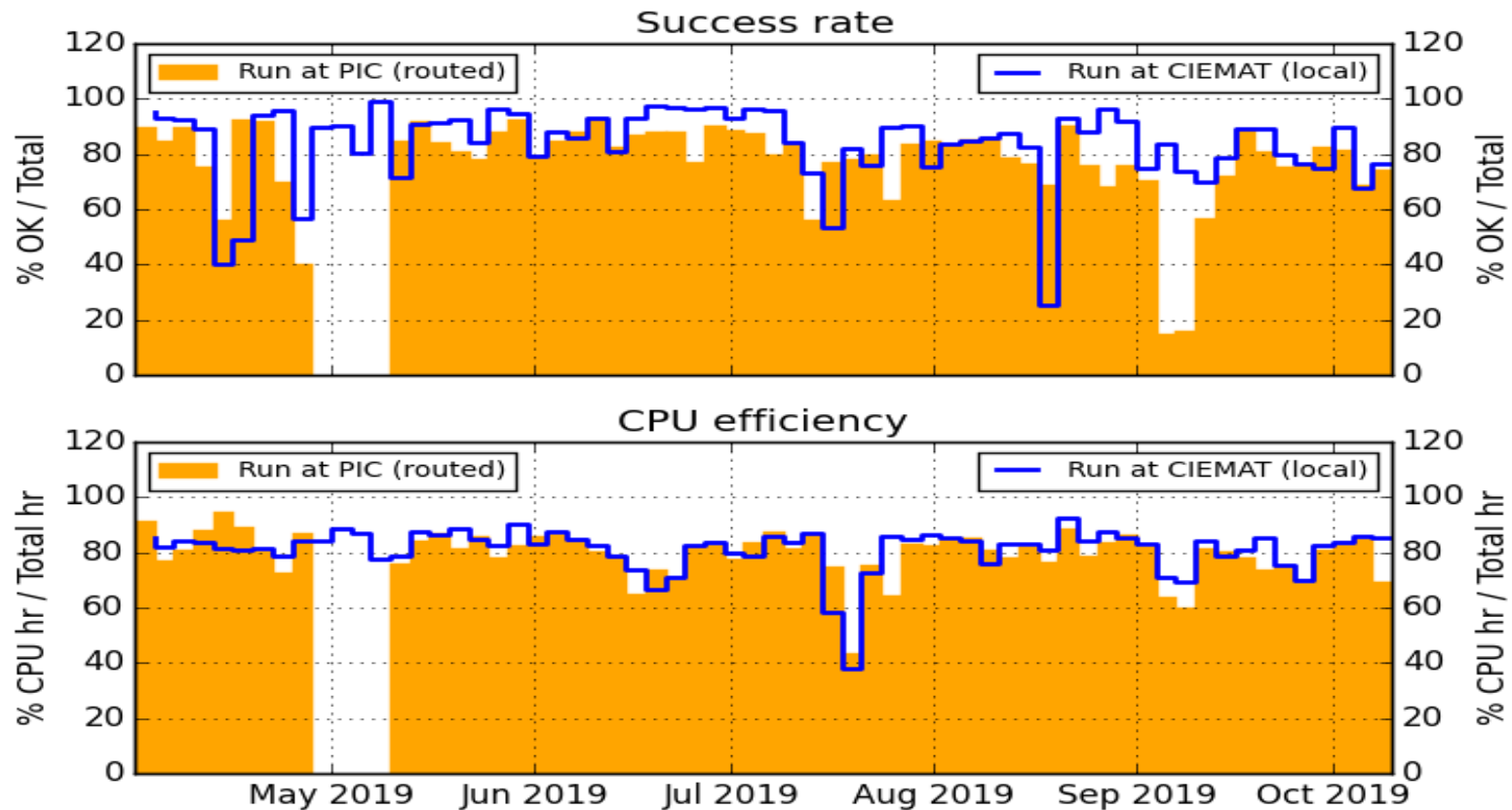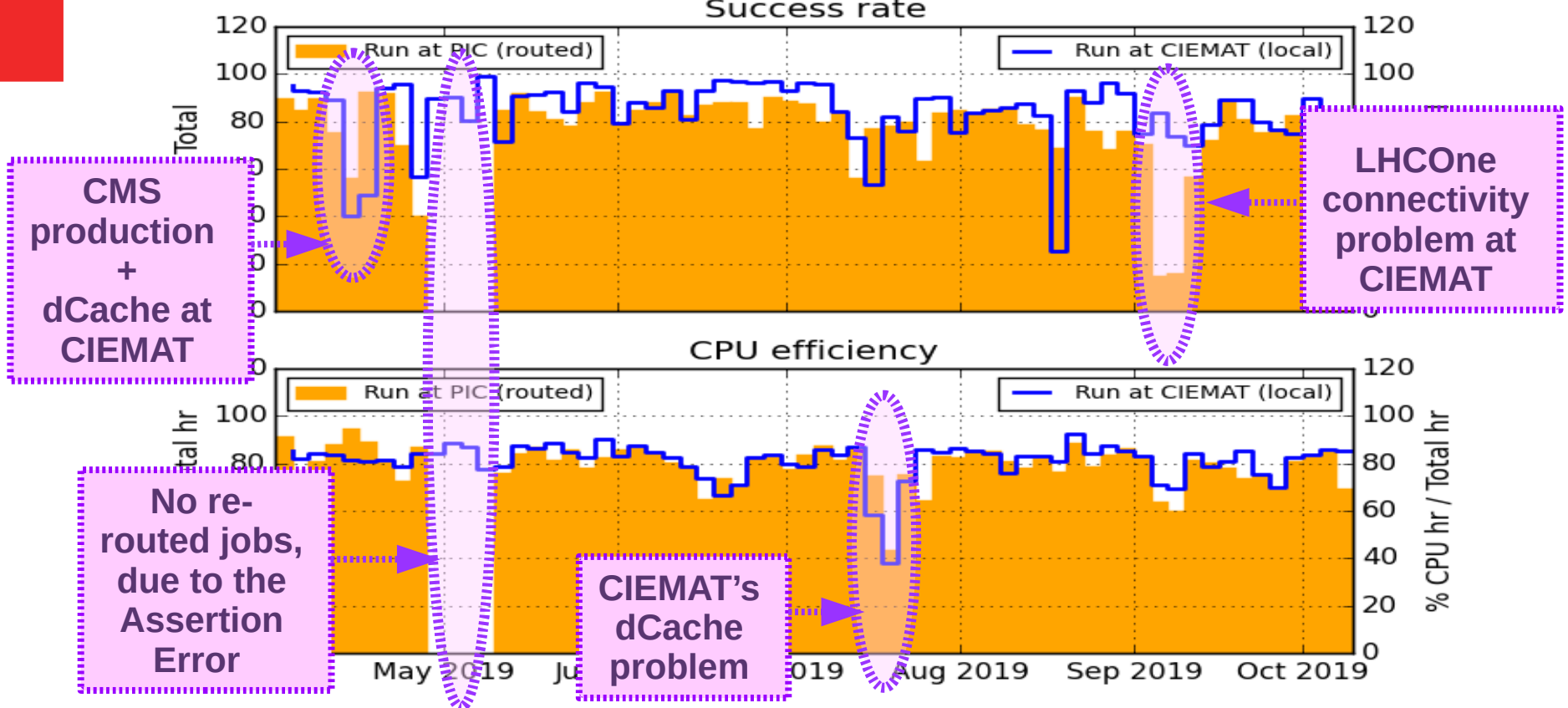Regional results show low (but
non-negligible) degradation

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Success/effic. for jobs meant for CIEMAT

Success/effic. for jobs meant for CIEMAT

Success rate

Legend: Run at PIC (routed), Run at CIEMAT (local)

CMS production + dCache at CIEMAT

LHCOne connectivity problem at CIEMAT

CPU efficiency

Legend: Run at PIC (routed), Run at CIEMAT (local)

No re-routed jobs, due to the Assertion Error

CIEMAT's dCache problem

May 2019   Jun   Jul 2019   Aug 2019   Sep 2019   Oct 2019

Impact of CMS xrootd activity

- Heavy external xrootd access to CIEMAT/PIC dCache degrades performance
  - Limited number of xrootd movers per pool
  - Long-duration of connections
  - Unpredictable access *storms* (many clients)

- Sites deploy separate WAN/LAN queues
  - But regional access uses WAN queue
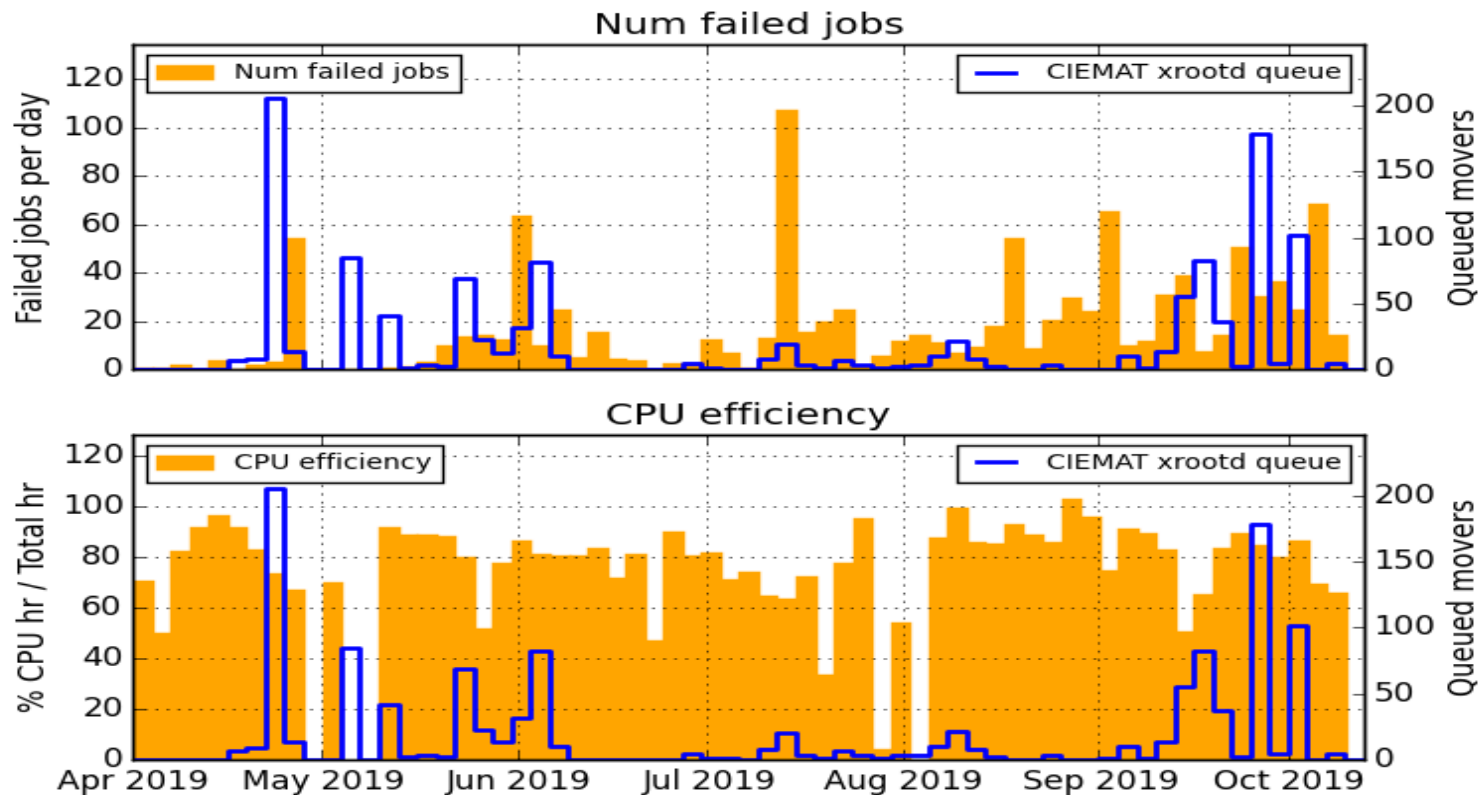 - ➔ Can be affected by external xrootd activity

Analysis jobs at CIEMAT reading from PIC vs PIC xrootd CLEANED
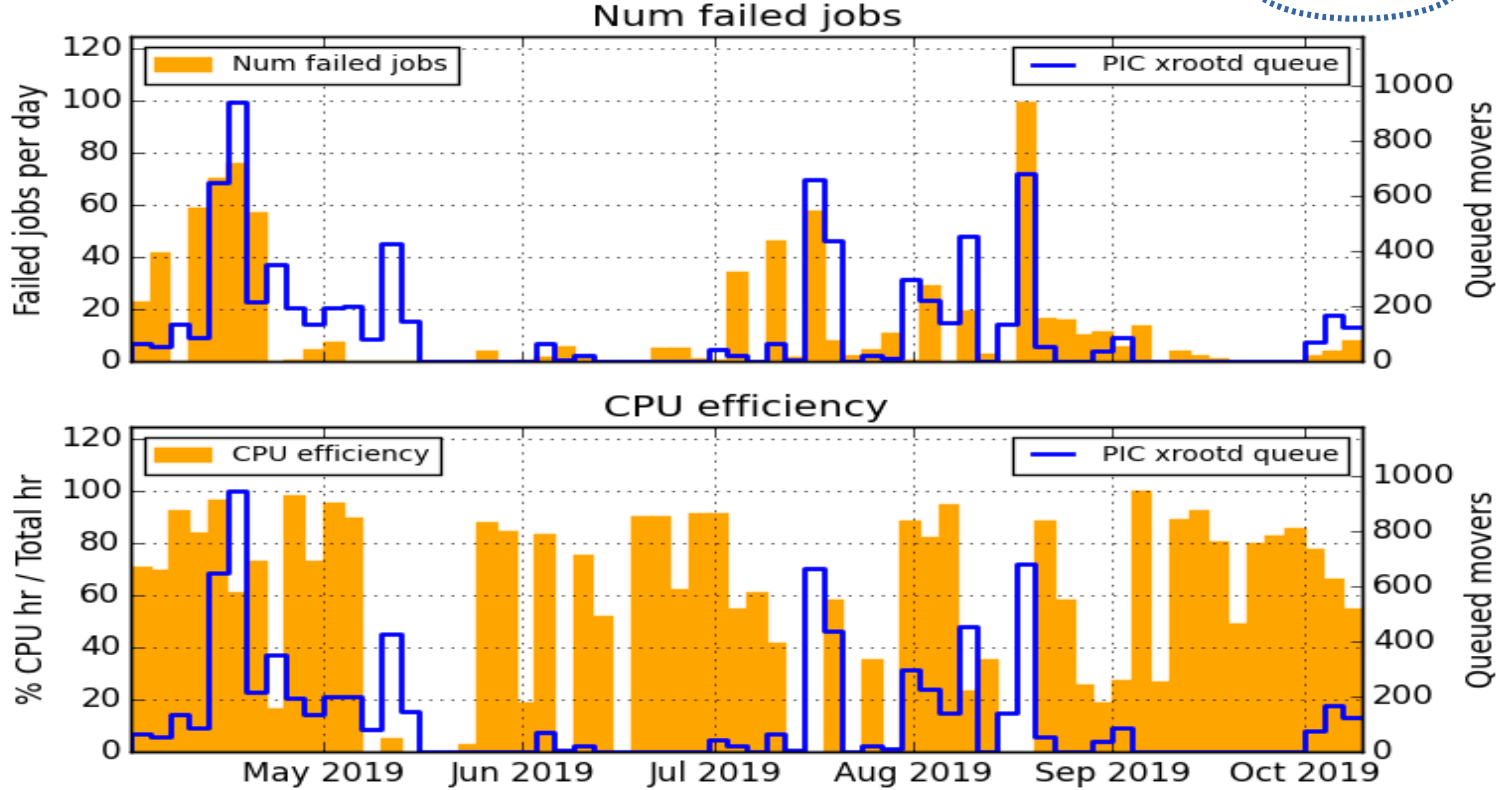
NOTE

To ease visual correlation, outliers >mean+3σ have been removed.

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Analysis jobs at PIC reading from CIEMAT vs CIEMAT xrootd CLEANED

Outline

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Conclusions

- The deployed lightweight federation has proven to work as expected
  - Most jobs *just work*, with limited efficiency degradation
  - A fraction of analysis jobs suffer somewhat higher degradation, but still tolerable

- Matching of *Merge* (and auxiliary) jobs on re-routed pilots should be avoided *(see next slide)*

- For larger scales, a dedicated regional xrootd mover queue on dCache might be advisable

Future work

- Modify pilots to match only certain types of jobs
  - New CMS *site-customizable pilots*

- Data caching for re-routed pilots use (e.g. *Xcache*)

- Re-evaluate mechanisms to federate HTCondor pools
  - Final solution might be a single regional HTCondor pool

- Work on better monitoring for finer-grain studies

- Extend to other regions?
  - Where latency is tolerable
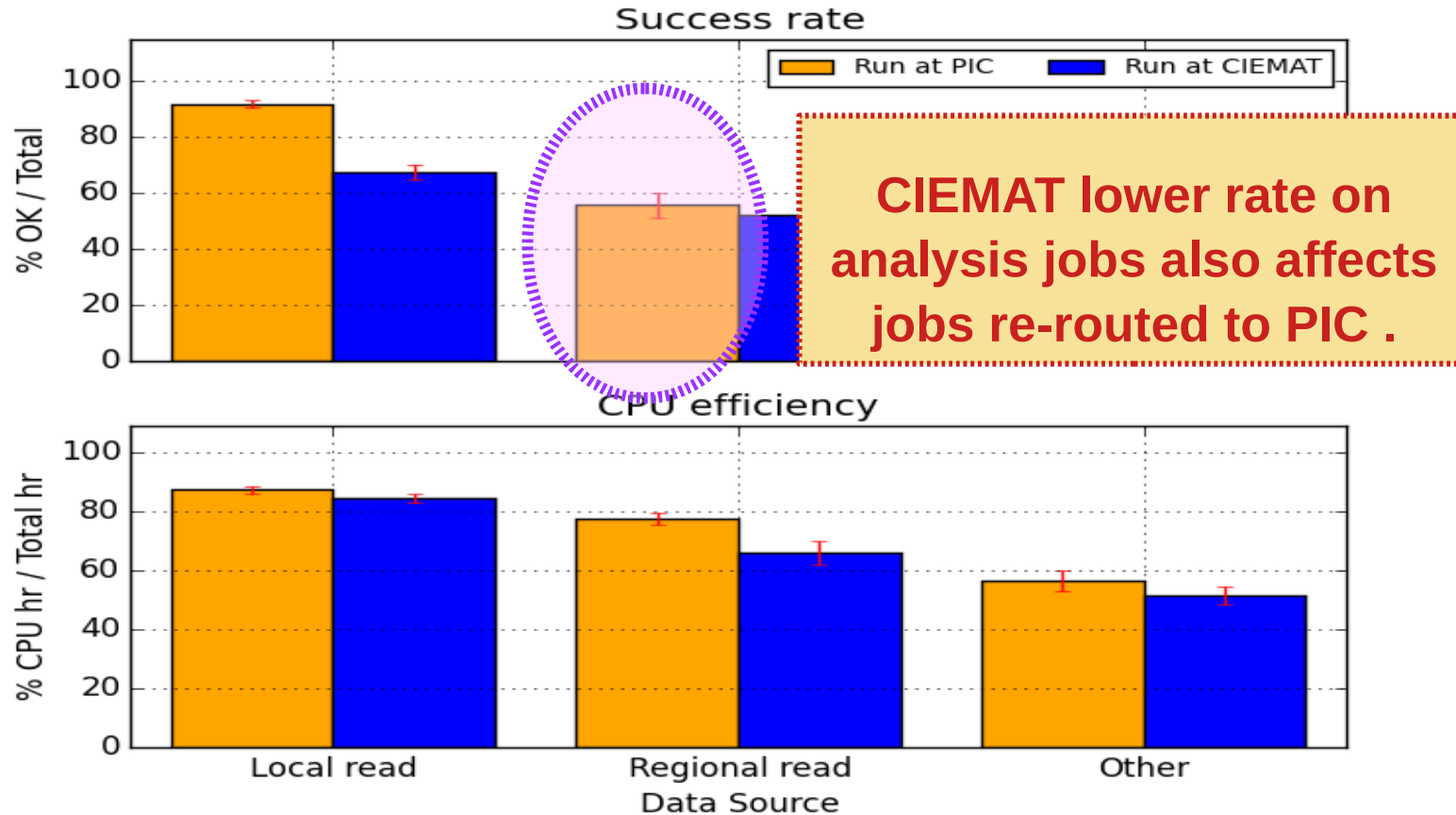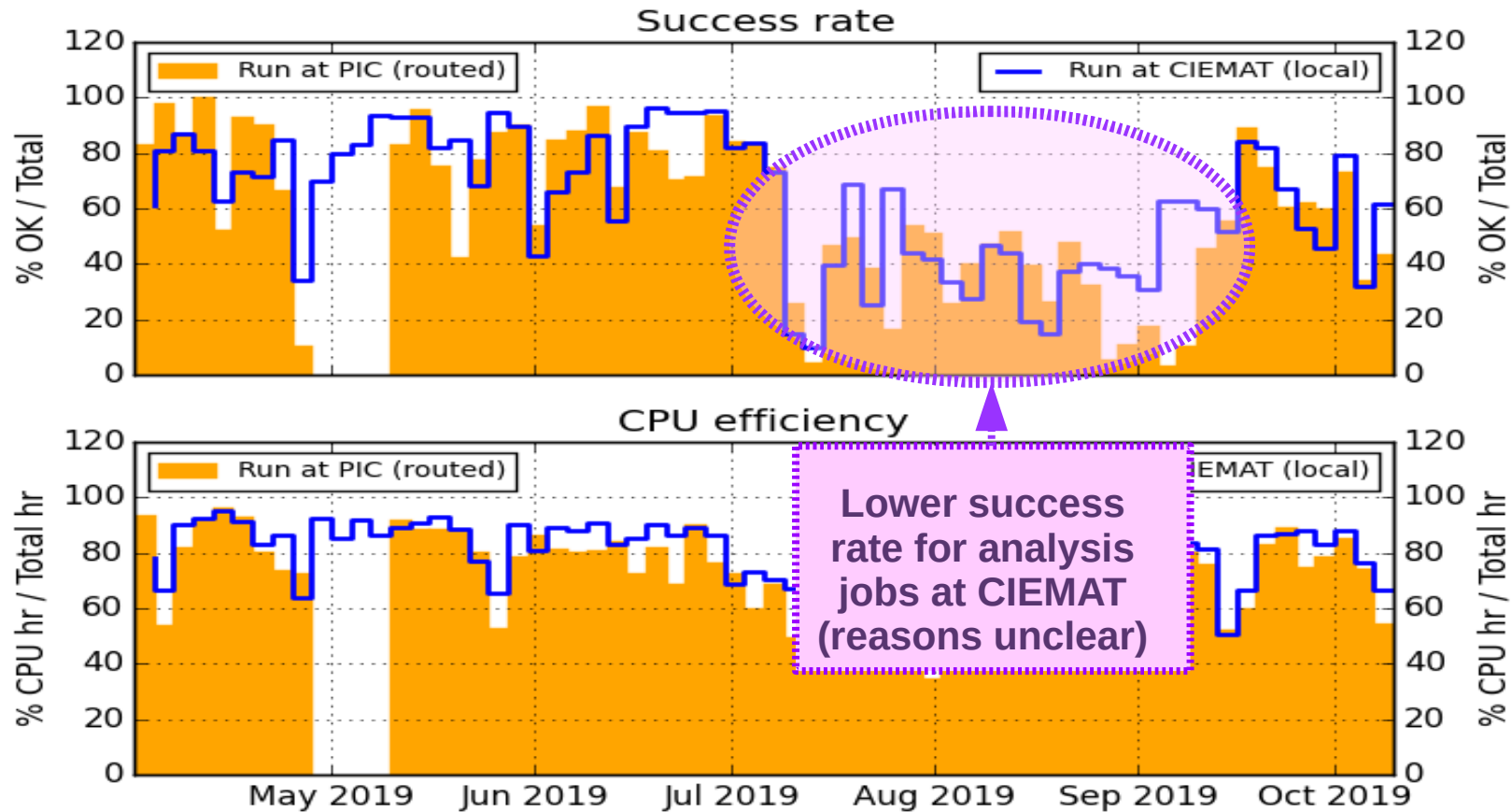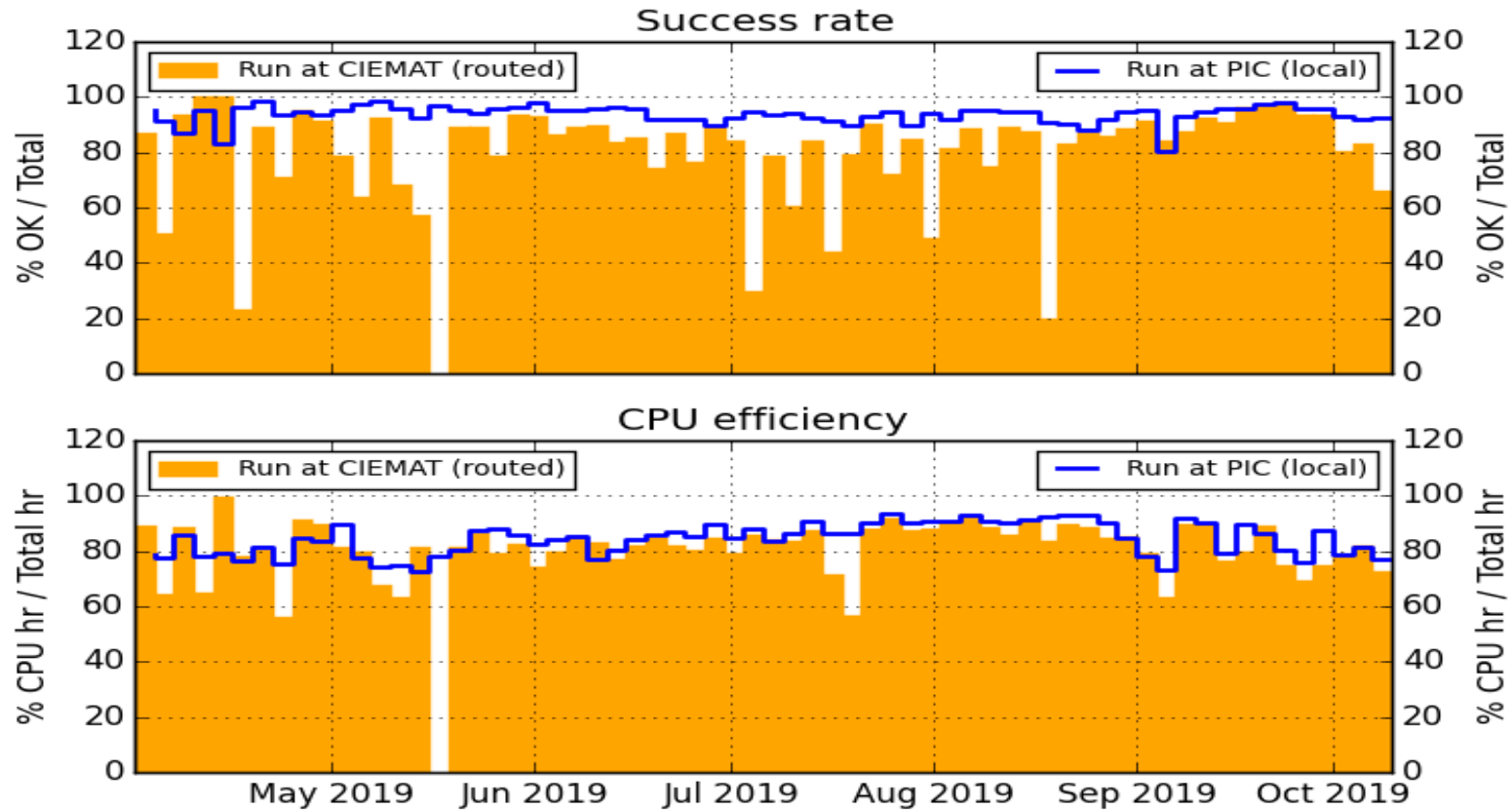
Thank you!

Questions?

Back-up Slides

European redirector

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Rates by read origin for analysis jobs

CIEMAT lower rate on analysis jobs also affects jobs re-routed to PIC .
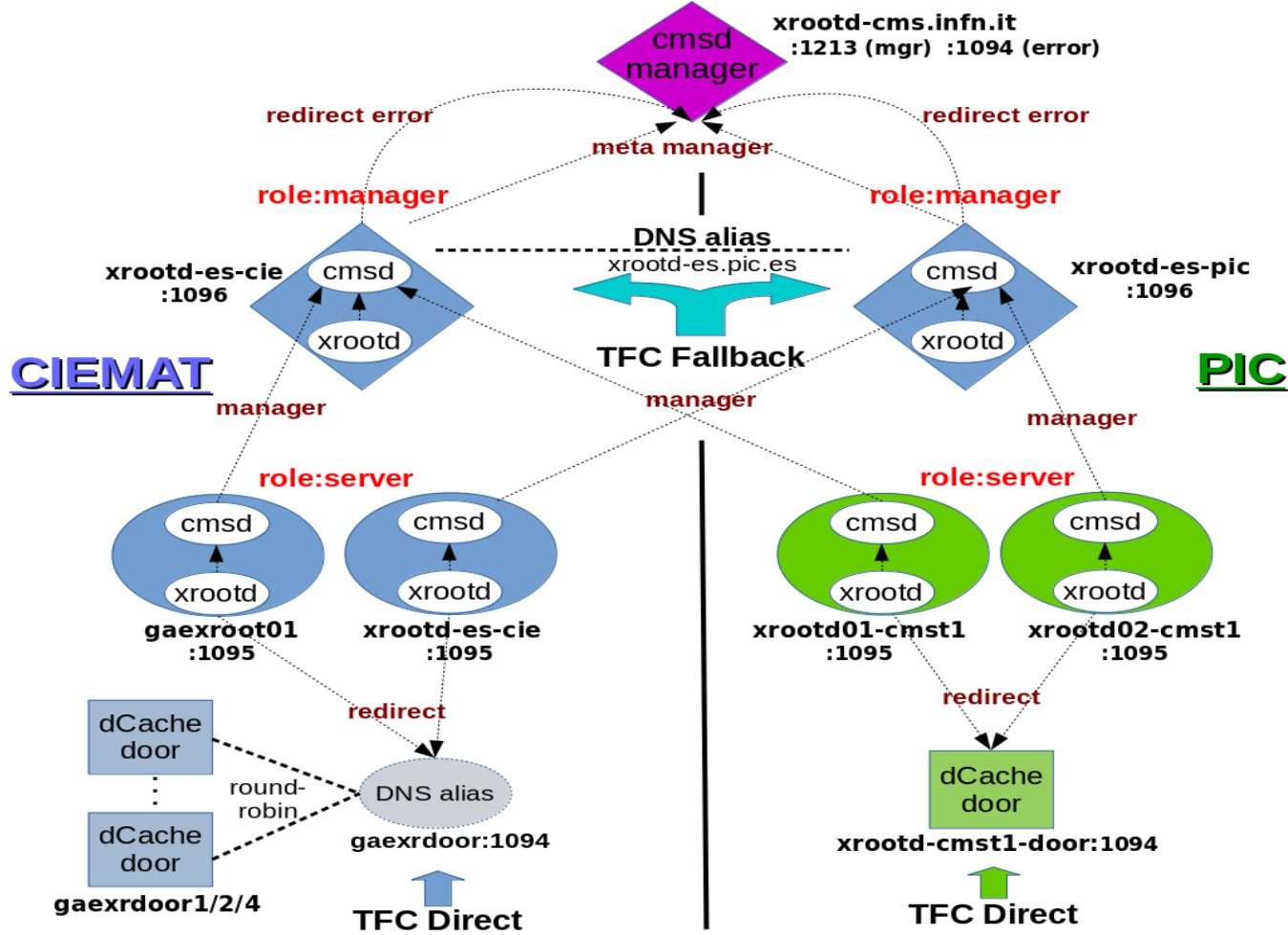
Success/effic. for jobs meant for CIEMAT (analysis only)

Success rate

Legend: Run at PIC (routed), Run at CIEMAT (local)

Y-axis: % OK / Total (0 to 120)

Lower success rate for analysis jobs at CIEMAT (reasons unclear)

CPU efficiency

Legend: Run at PIC (routed), ...EMAT (local)

Y-axis: % CPU hr / Total hr (0 to 120)

X-axis: May 2019, Jun 2019, Jul 2019, Aug 2019, Sep 2019, Oct 2019

Success/effic. for jobs meant for PIC

Success rate

Run at CIEMAT (routed)
Run at PIC (local)

CPU efficiency

Run at CIEMAT (routed)
Run at PIC (local)

May 2019   Jun 2019   Jul 2019   Aug 2019   Sep 2019   Oct 2019

Success/effic. for jobs meant for PIC

Success rate
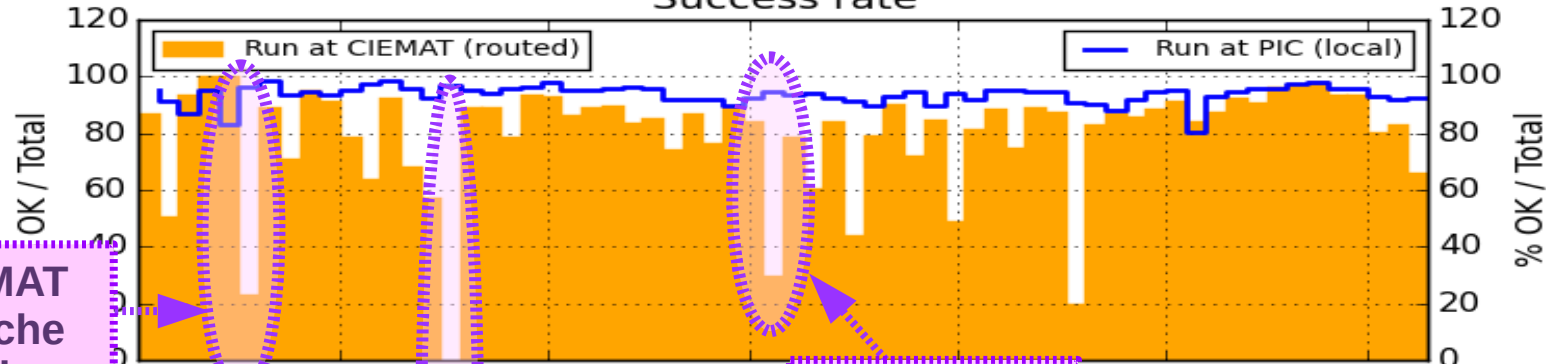
CIEMAT dCache problem

Single user declaring data at PIC but reading from USA

CPU eff.

No re-routed jobs (network problem)

Run at CIEMAT (routed) Run at PIC (local)

2019 Jun 2019 Jul 2019 Aug 2019 Sep 2019 Oct 2019
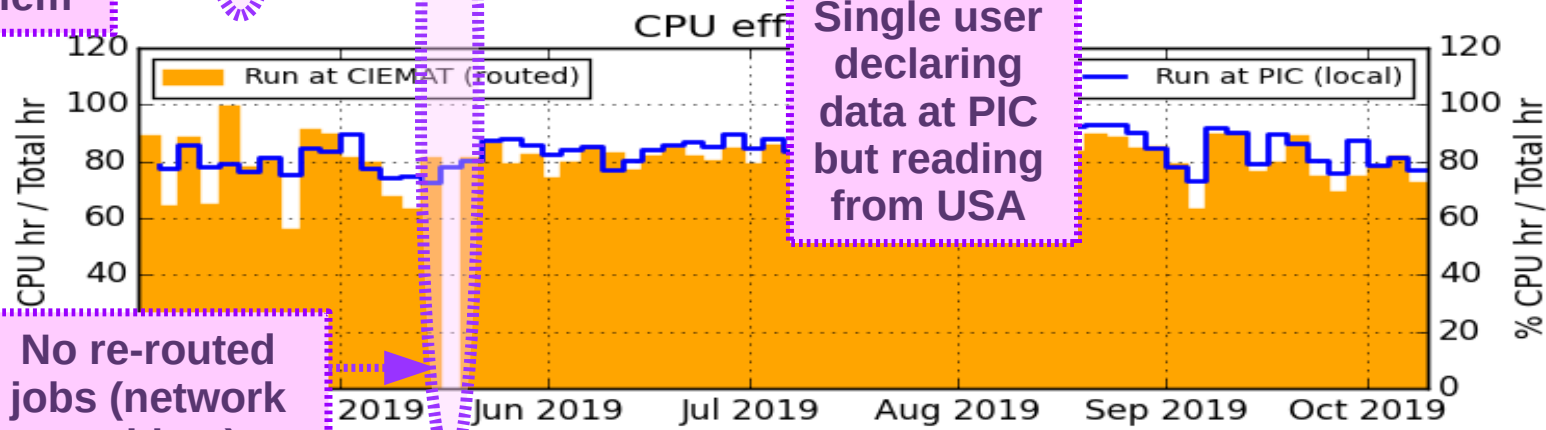
Production jobs at CIEMAT vs PIC xrootd
CLEANED
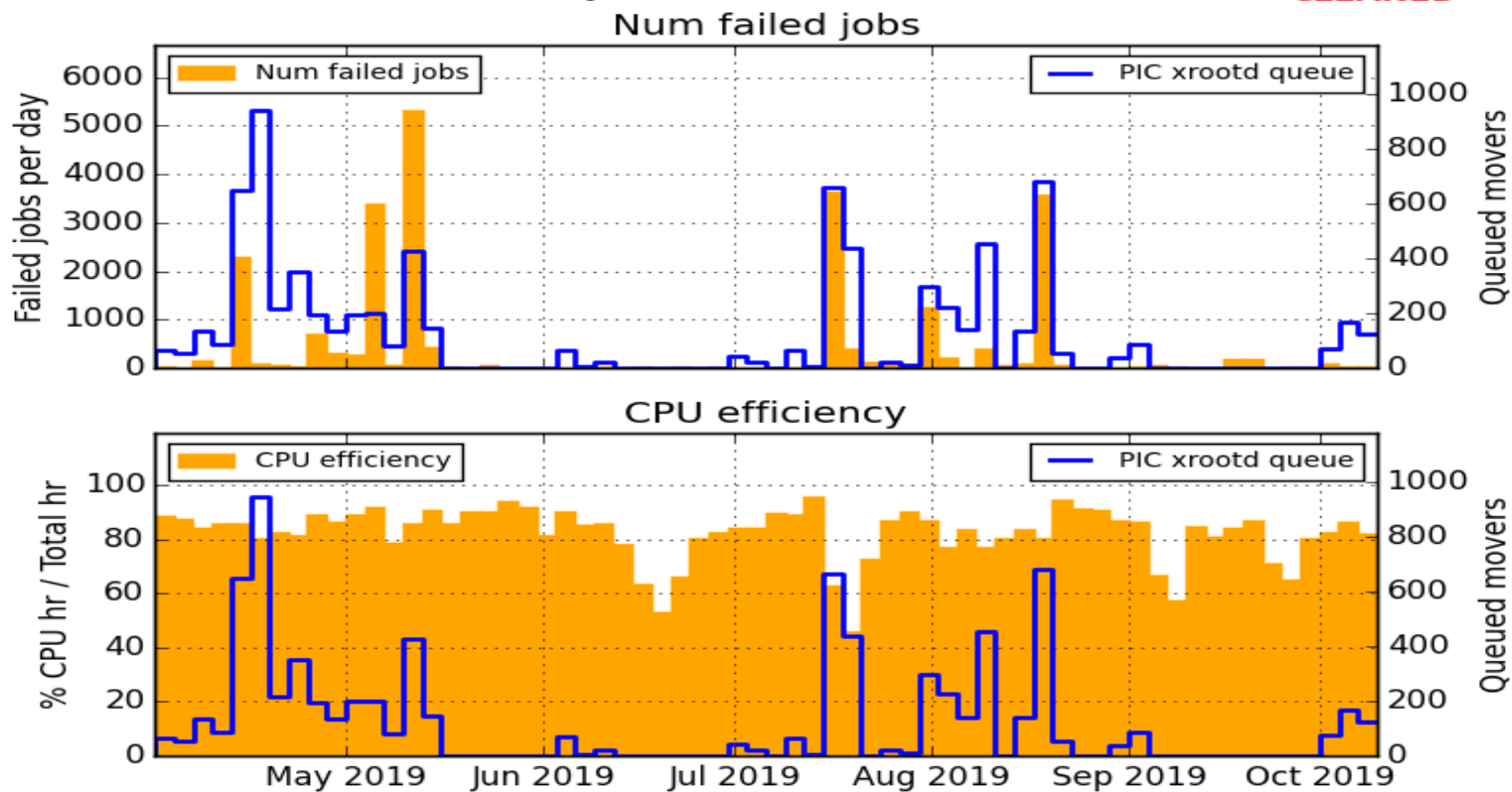
CIEMAT: Number of failed jobs per job type (thousands/day)
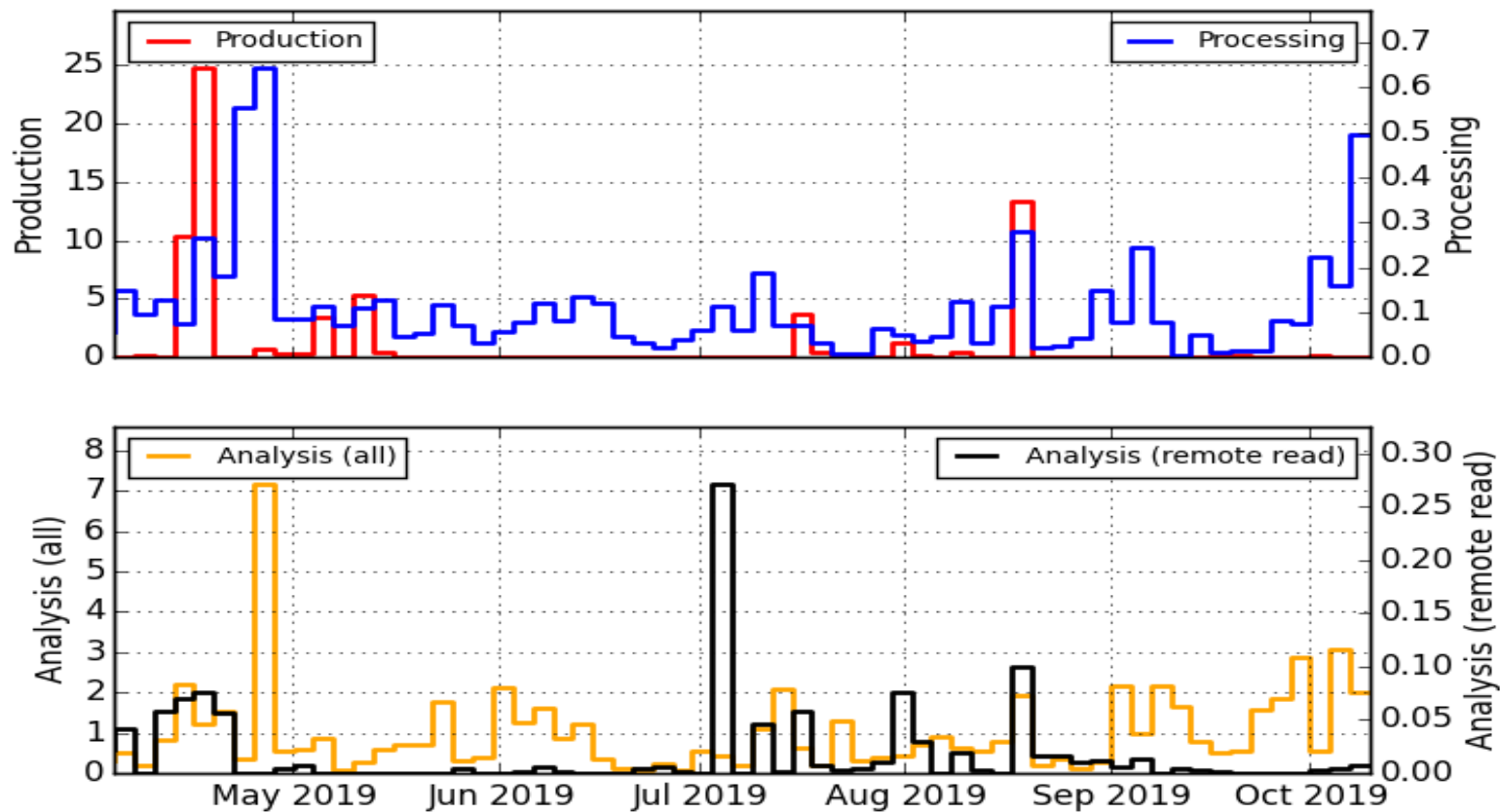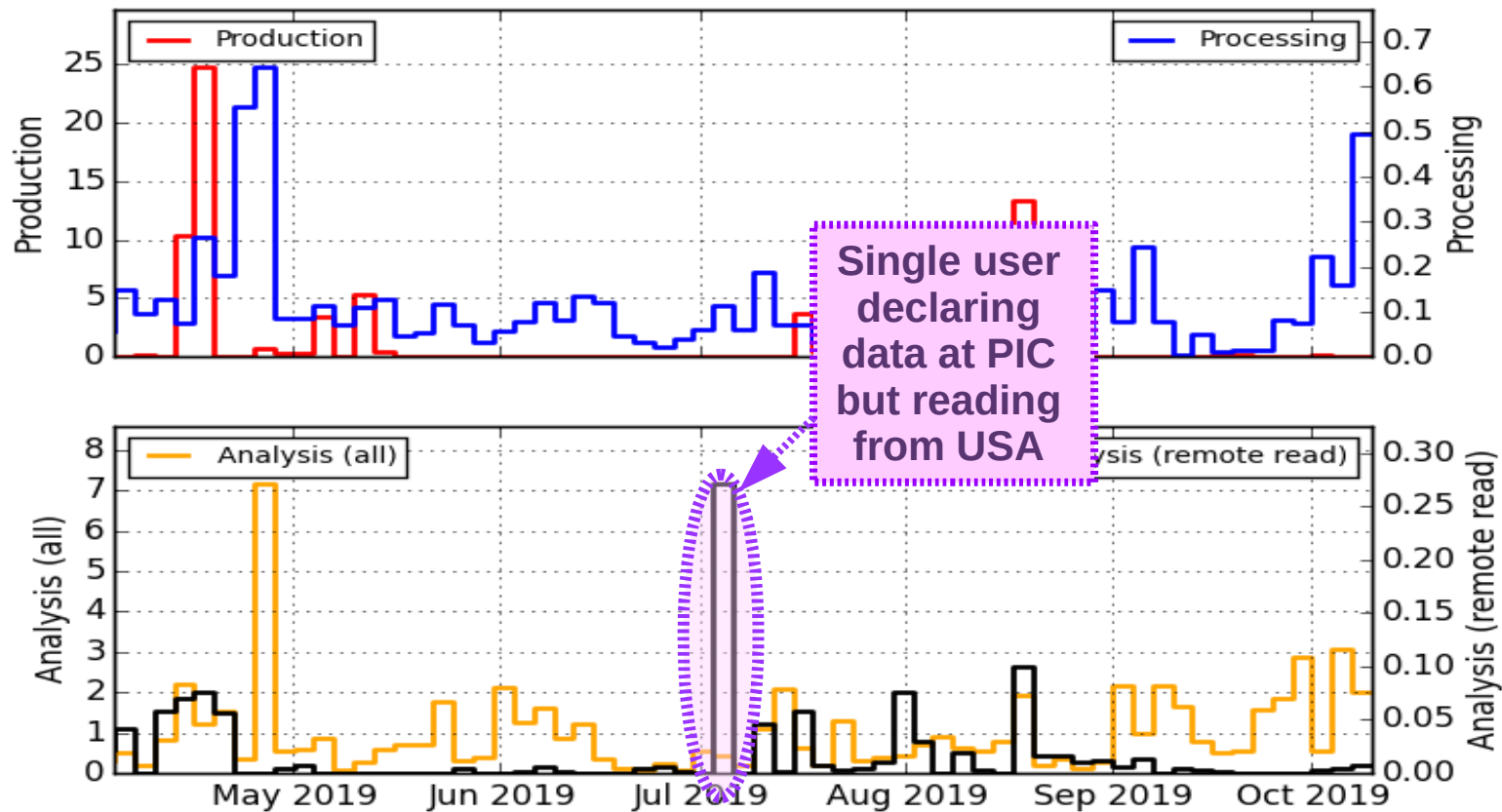
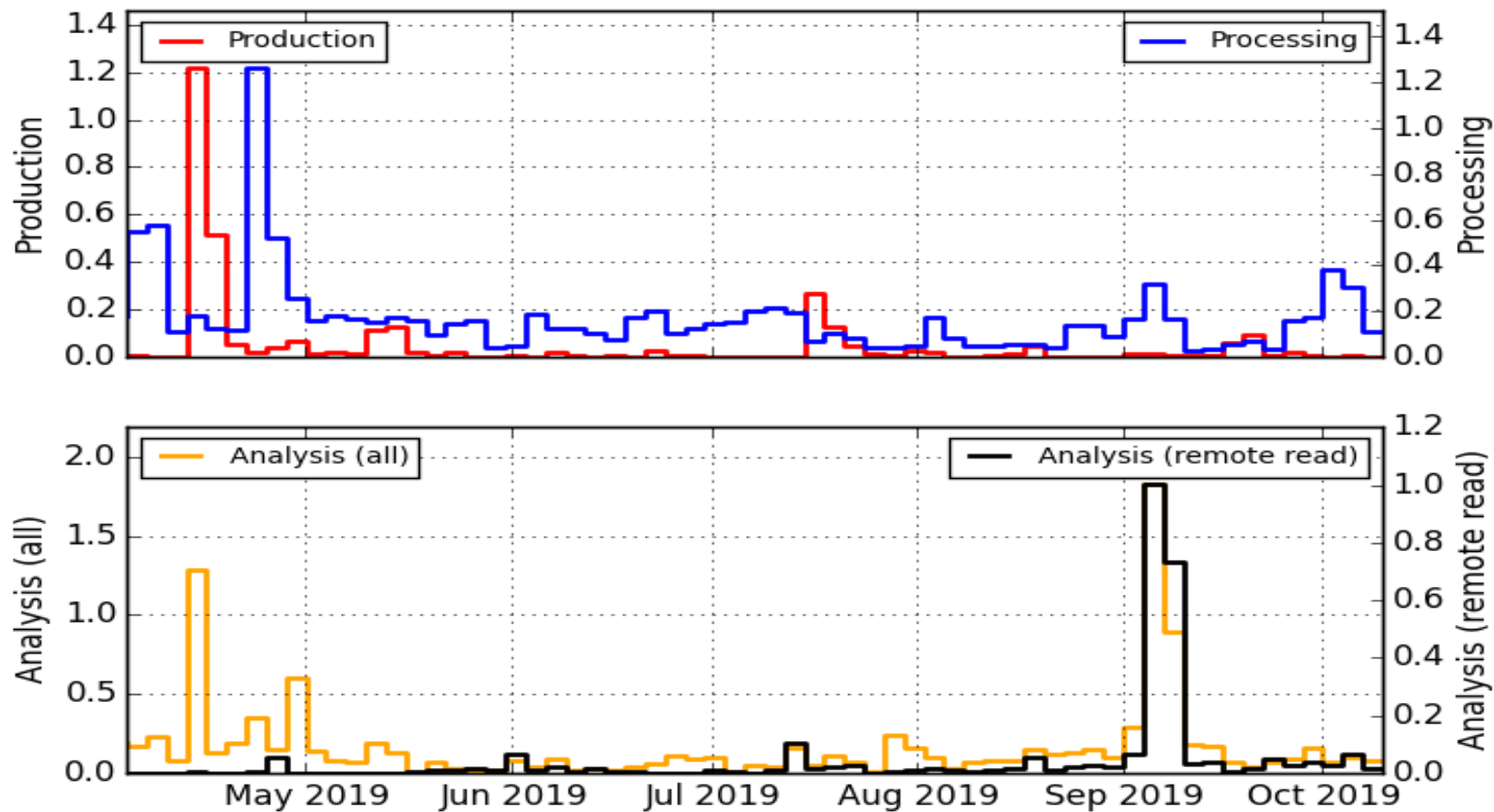**CIEMAT: Number of failed jobs per job type (thousands/day)**
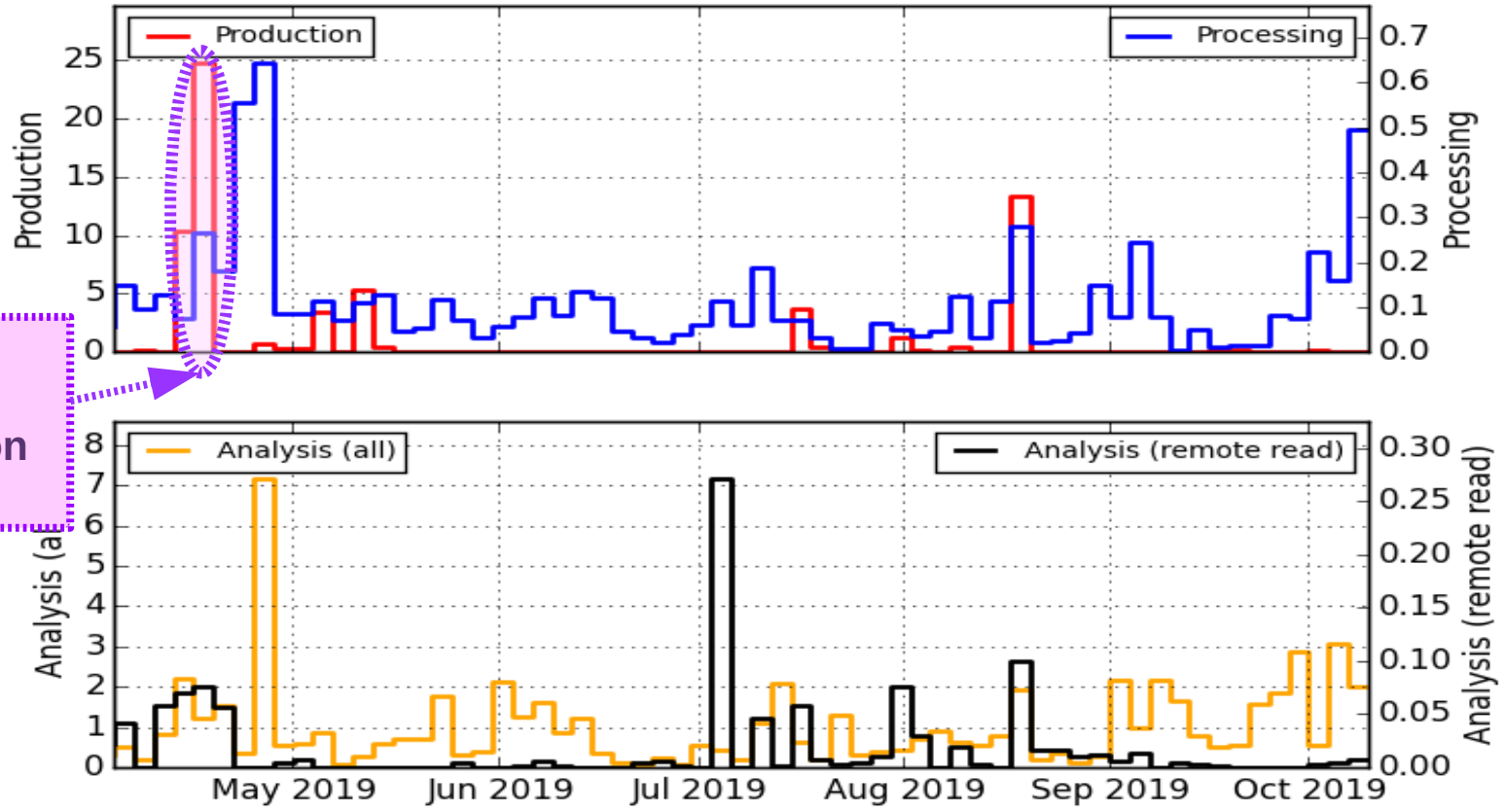
General CMS production problem

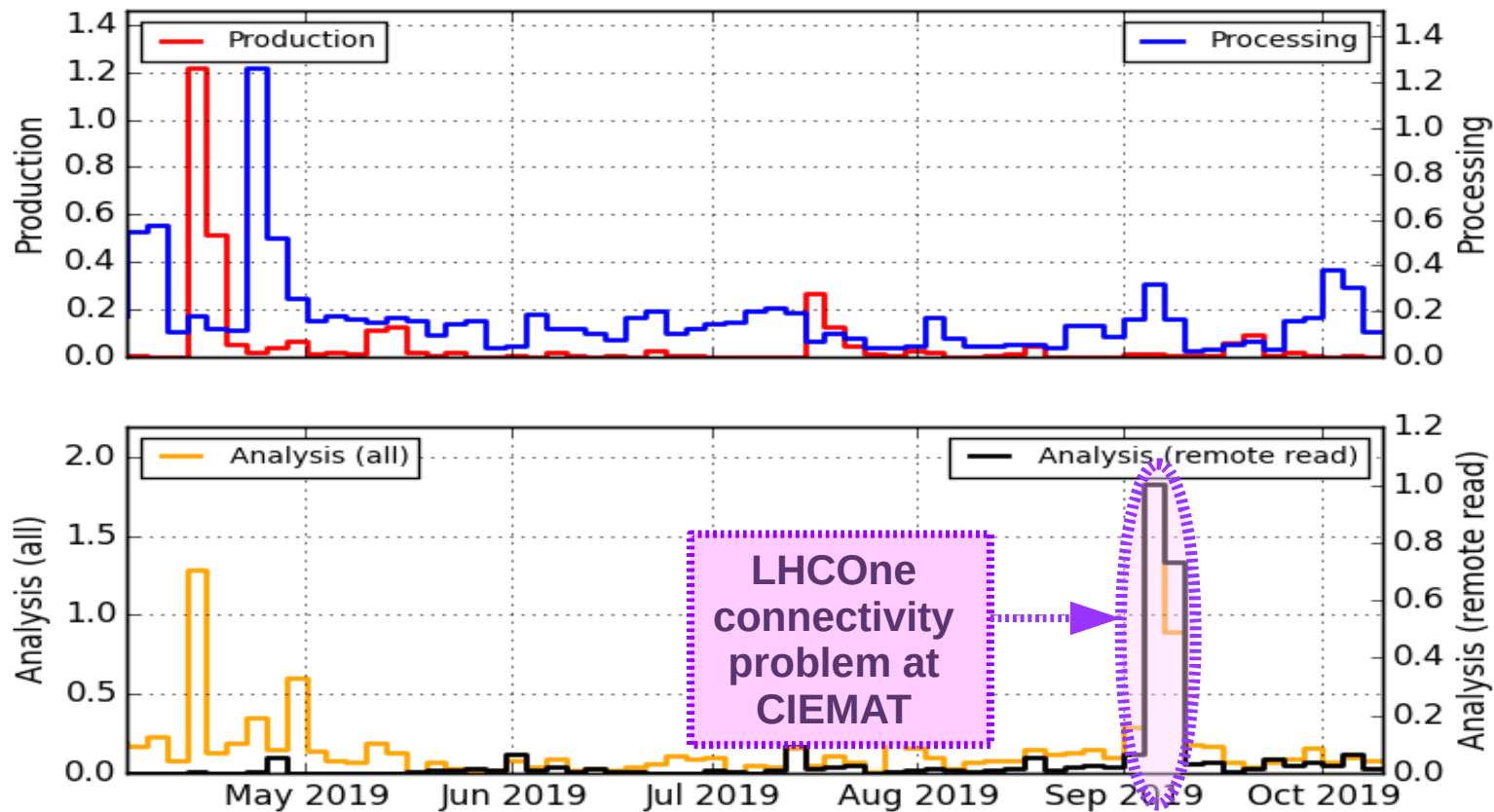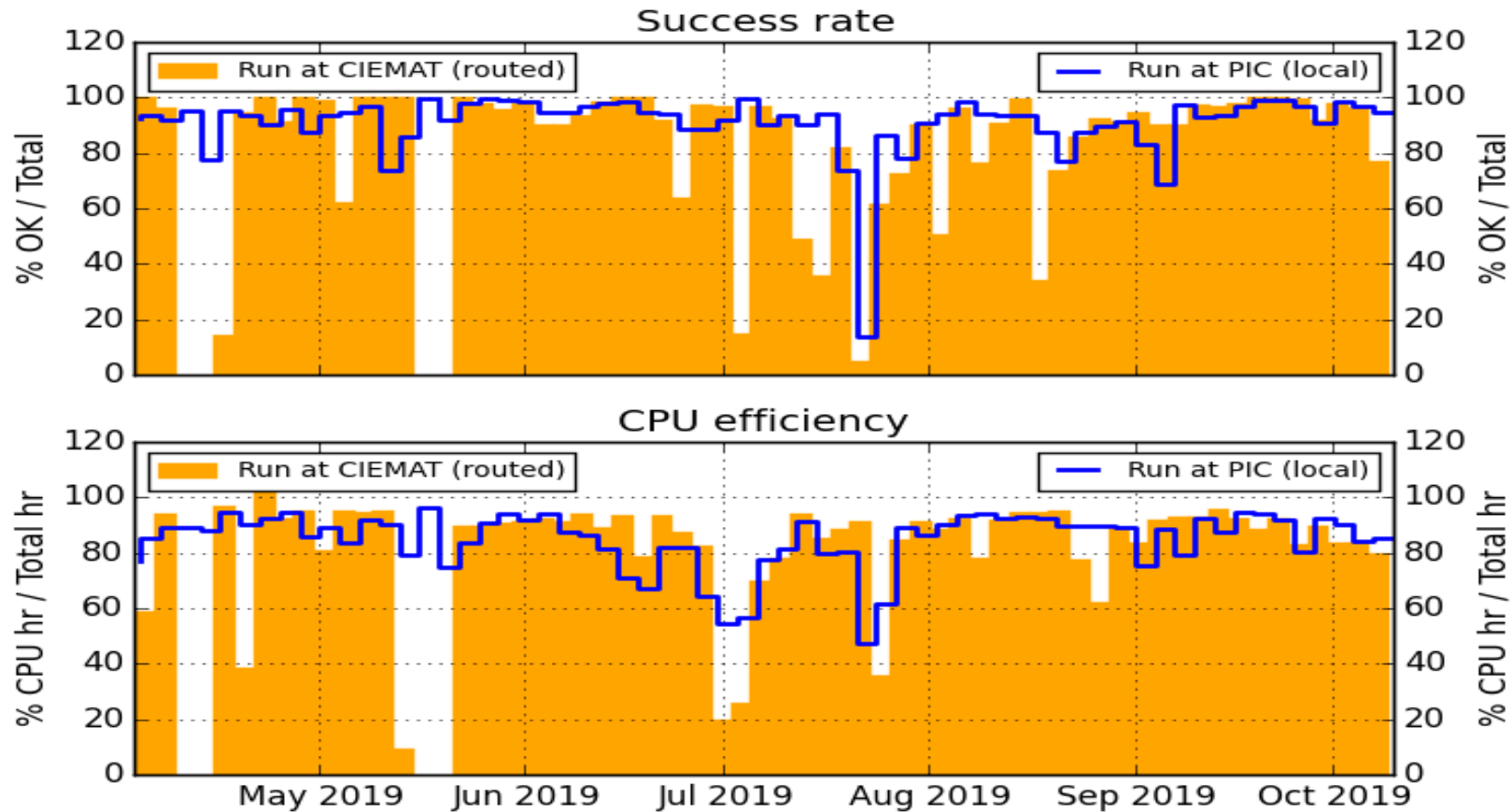CIEMAT: Number of failed jobs per job type (thousands/day)

CIEMAT dCache problem

CIEMAT: Number of failed jobs per job type (thousands/day)

Single user declaring data at PIC but reading from USA
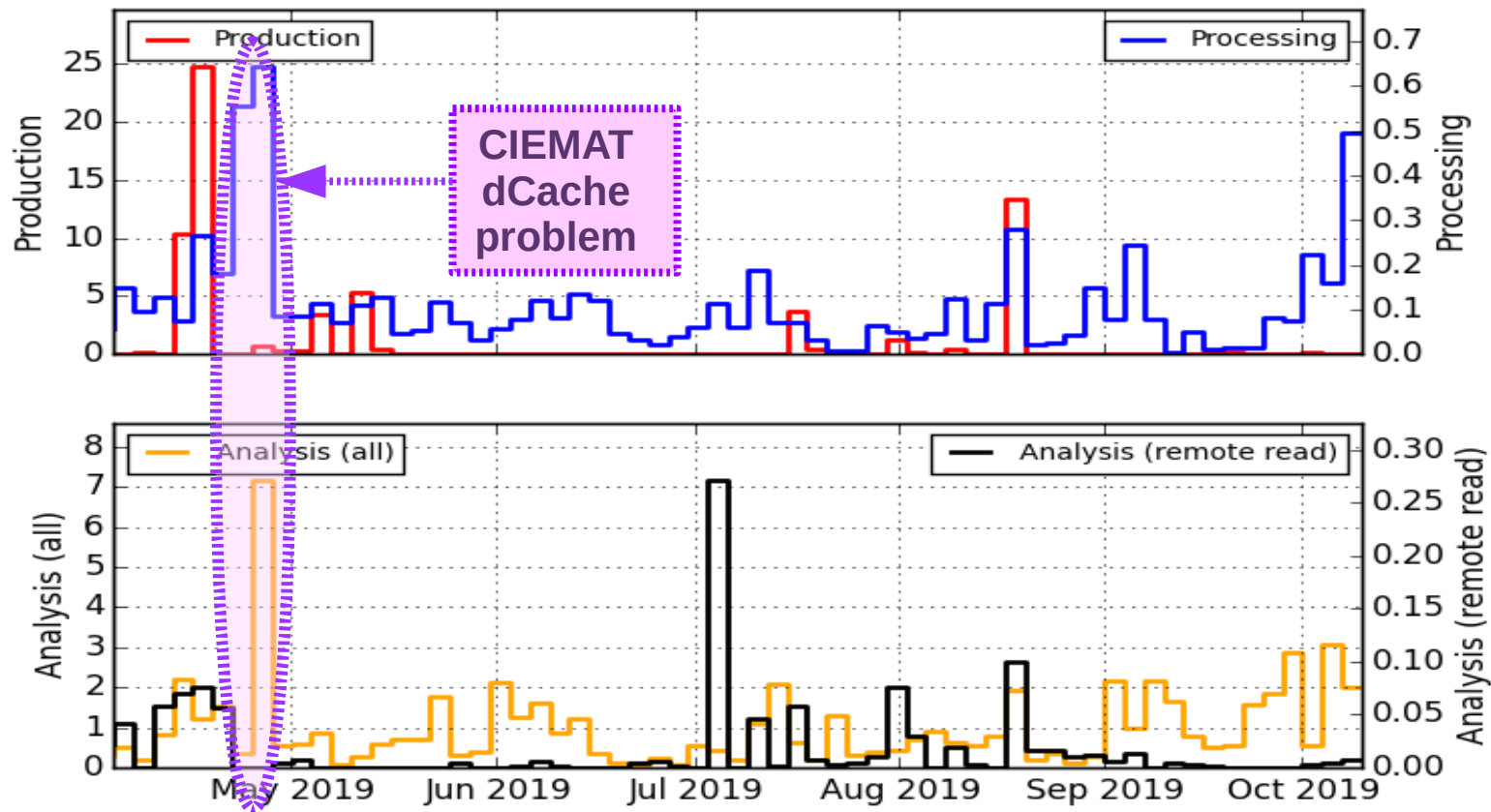
PIC: Number of failed jobs per job type (thousands/day)

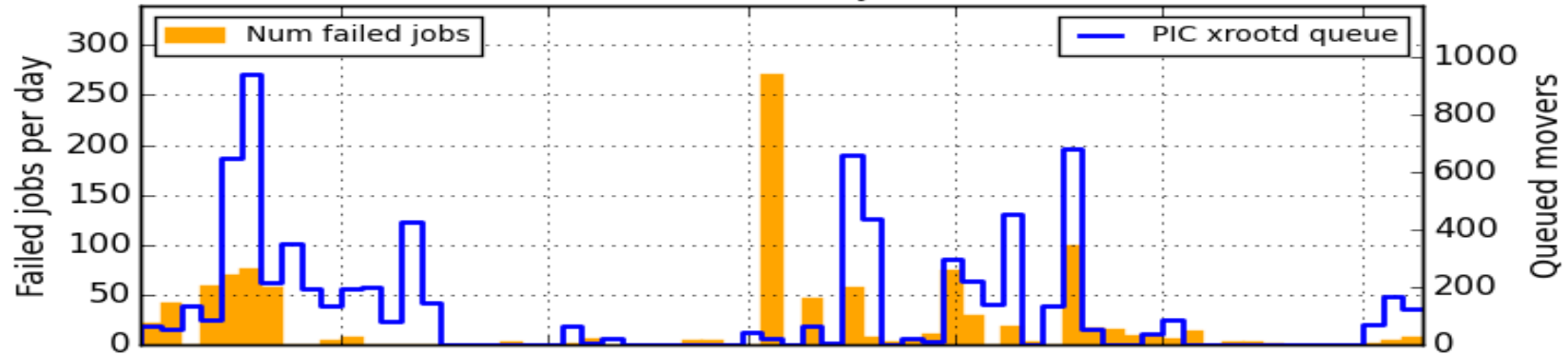# PIC: Number of failed jobs per job type (thousands/day)

LHCOne connectivity problem at CIEMAT

Success/effic. for jobs meant for PIC (analysis only)

Analysis jobs at CIEMAT reading from PIC vs PIC xrootd

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Production jobs at CIEMAT vs PIC xrootd

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Analysis jobs at PIC reading from CIEMAT vs CIEMAT xrootd