The ATLAS Distributed Analysis System

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on behalf of the ATLAS collaboration

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LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

Outline

- Distributed Analysis in ATLAS during **LHC run 1**:
  - Computing model: *Job goes to data* paradigm
  - Distributed analysis: performance
    - **Statistics**
    - **Efficiency**
    - **Failures**
    - **Data types**

- Future developments and implications on distributed analysis for **run 2**:
  - new **production system**
  - new **analysis model**
  - **remote file access**

ATLAS Computing Model 2011-2013

ATLAS Grid infrastructure

This talk

Central production & Distributed Data Management (DDM)

T0 → T1, T2

Data processing

MC production

T1-T2

DDM: dq2

Size: PB

AOD: Analysis Object Data

Group production

Size: PB

D3PD: flat ntuple

Distributed Analysis

T1-T2 TB

derived formats

Group Analysis

User Analysis

T1-T2-T3

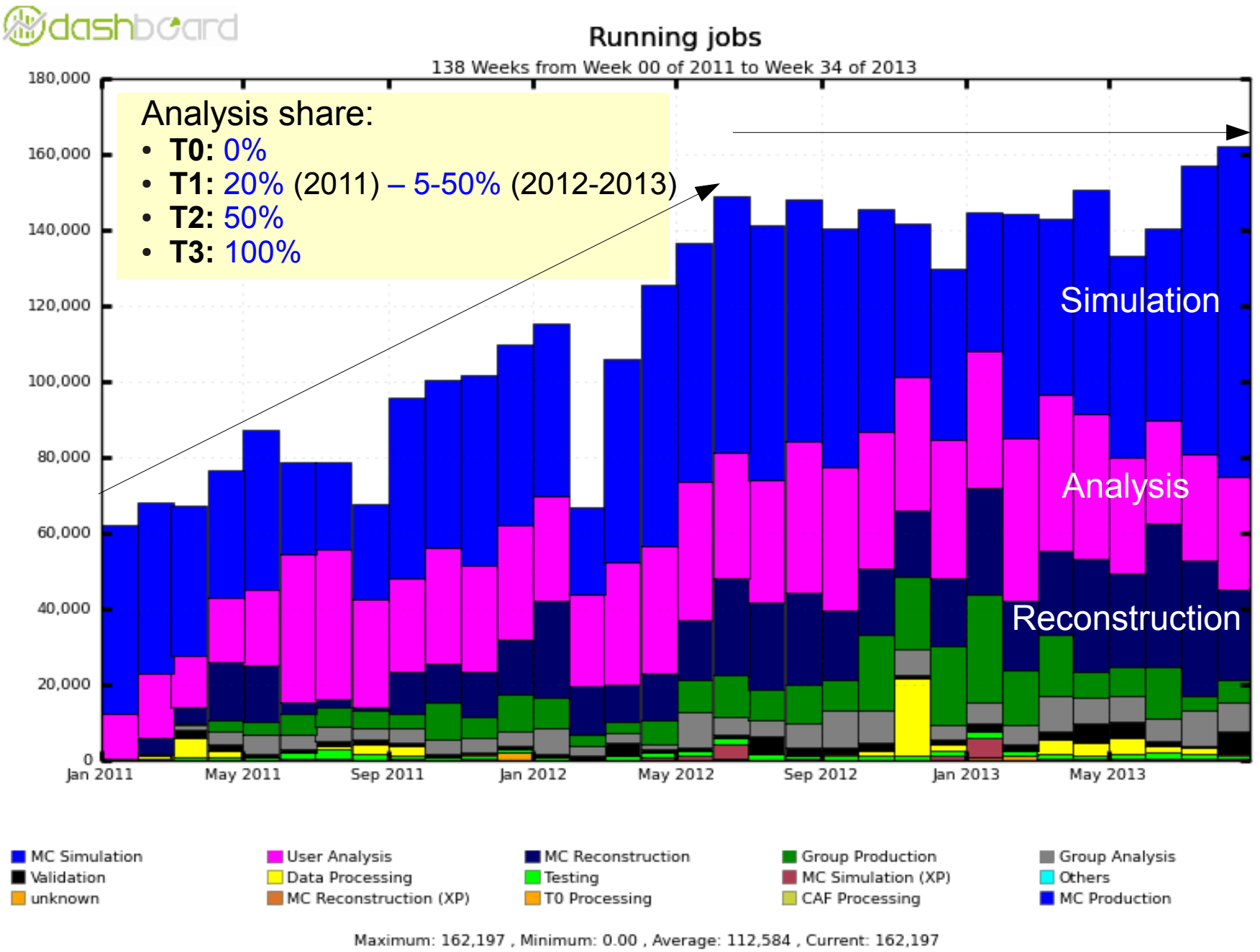
Size: GB

User tools for grid job submission:

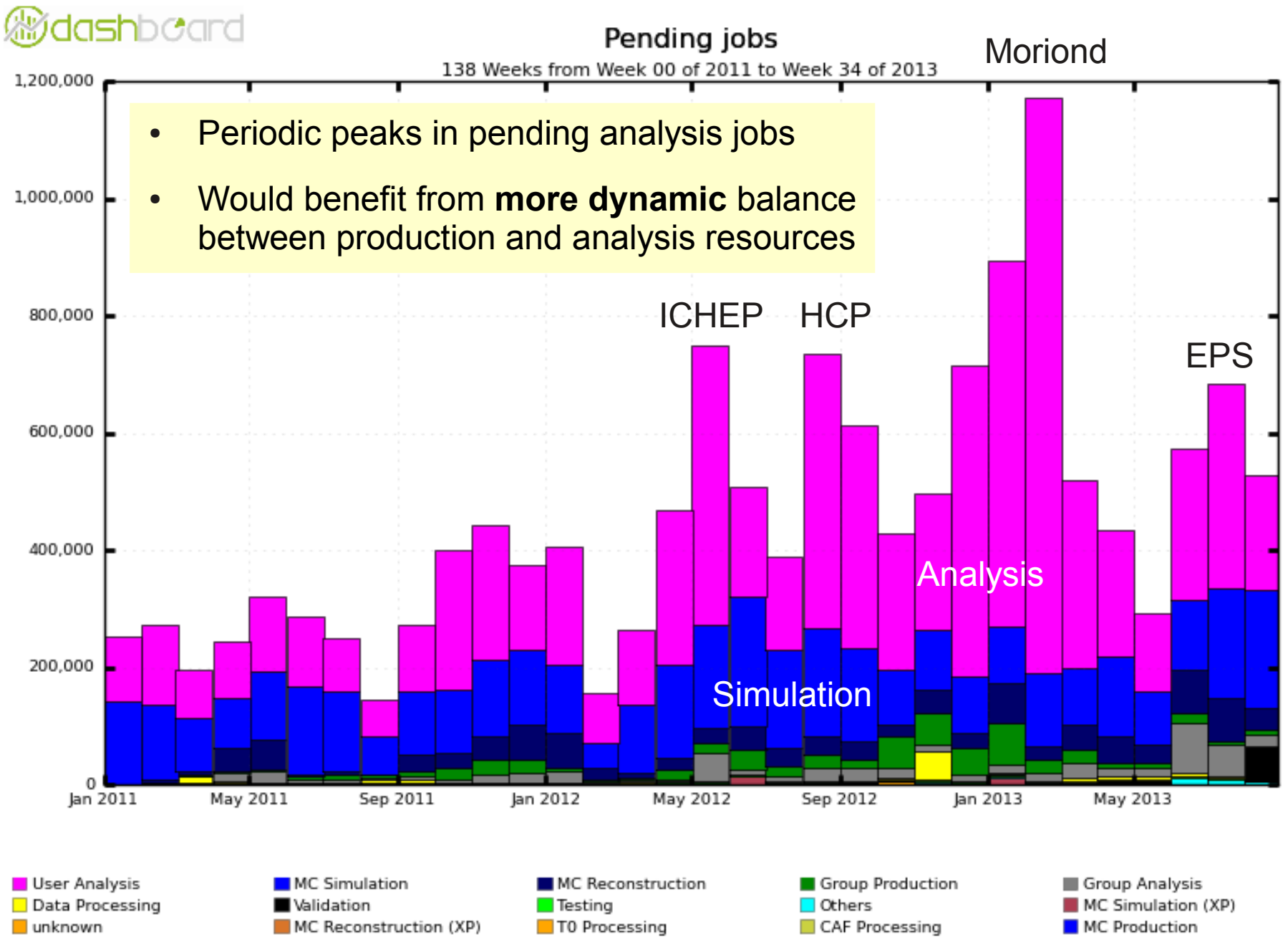
- PanDA
- Ganga

Paradigm: job goes to data

Running Grid jobs 2011-2013



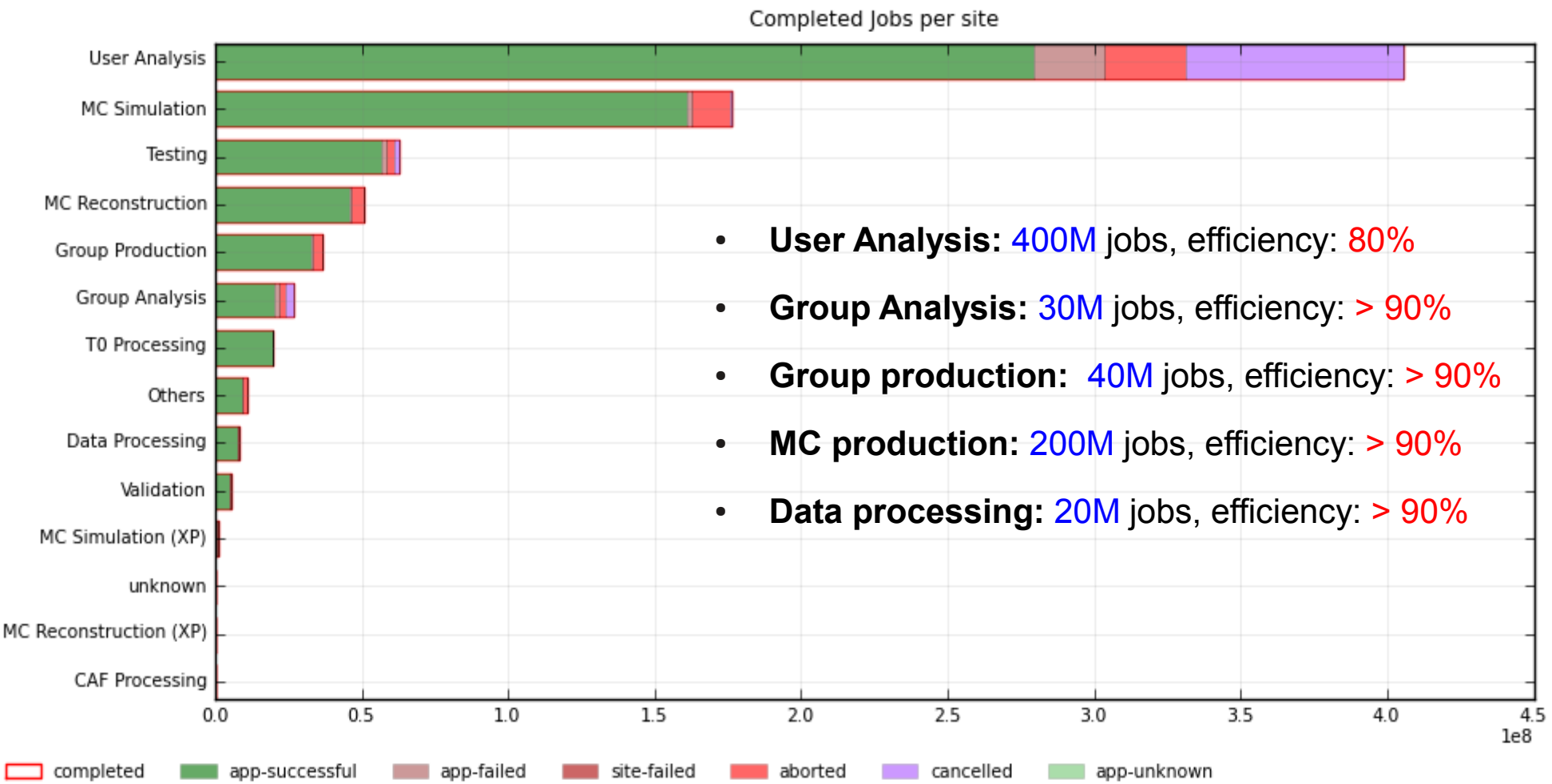
Pending Grid jobs 2011-2013



- Periodic peaks in pending analysis jobs
- Would benefit from **more dynamic** balance between production and analysis resources

ATLAS Grid jobs 2011-2013

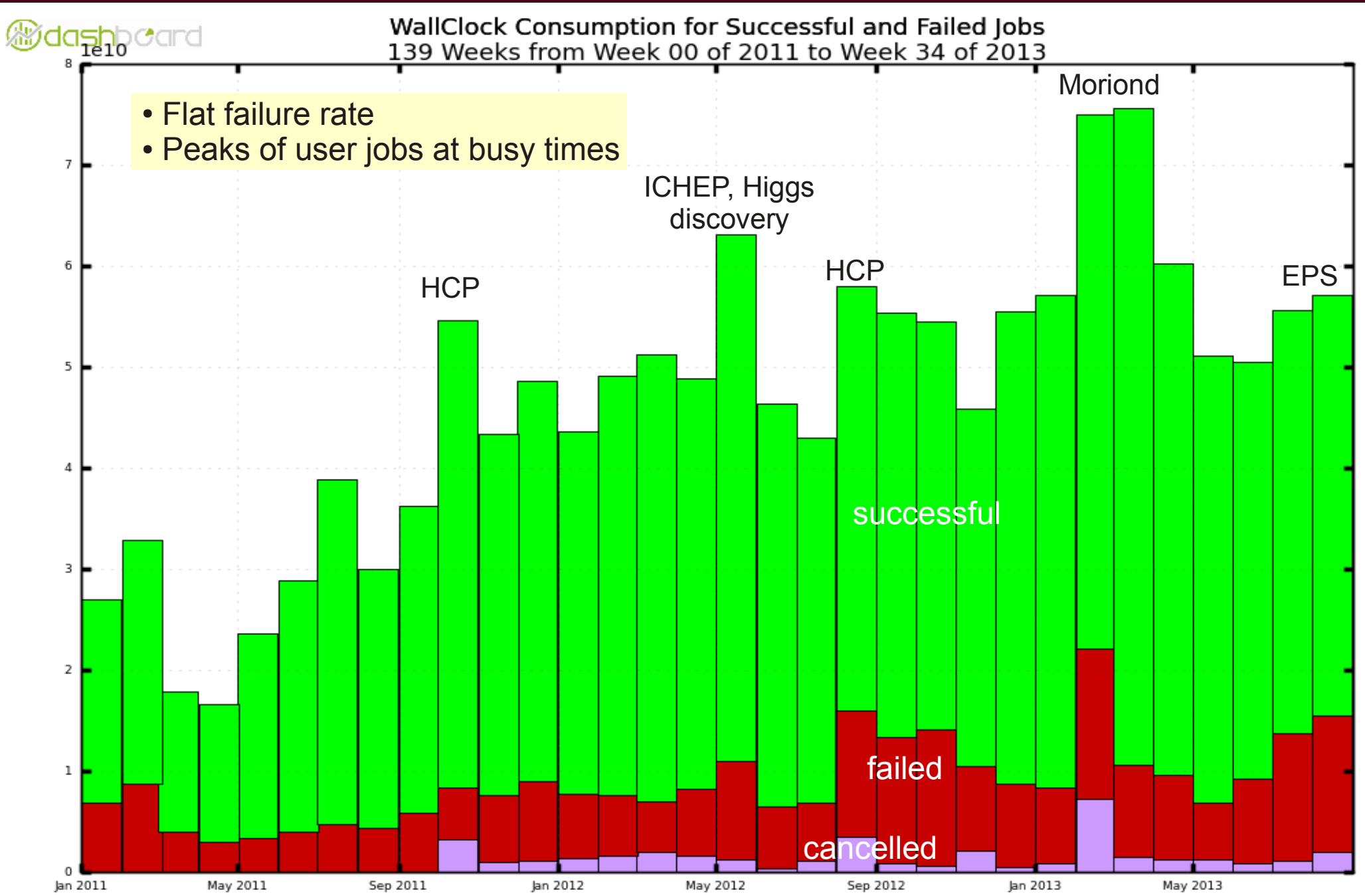
5% grid-related failure rate, mostly due to storage failures



- **User Analysis:** 400M jobs, efficiency: 80%
- **Group Analysis:** 30M jobs, efficiency: > 90%
- **Group production:** 40M jobs, efficiency: > 90%
- **MC production:** 200M jobs, efficiency: > 90%
- **Data processing:** 20M jobs, efficiency: > 90%

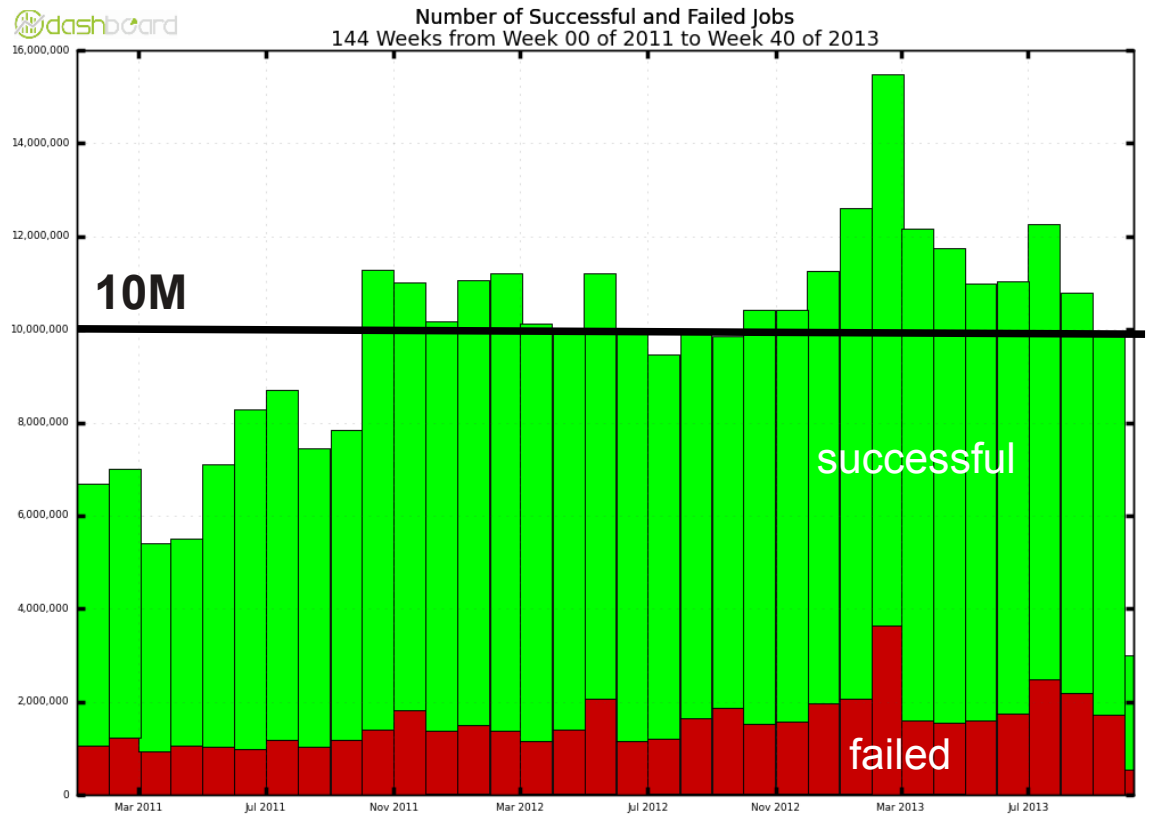
(NB cancelled jobs have walltime close to 0, negligible impact on efficiency)

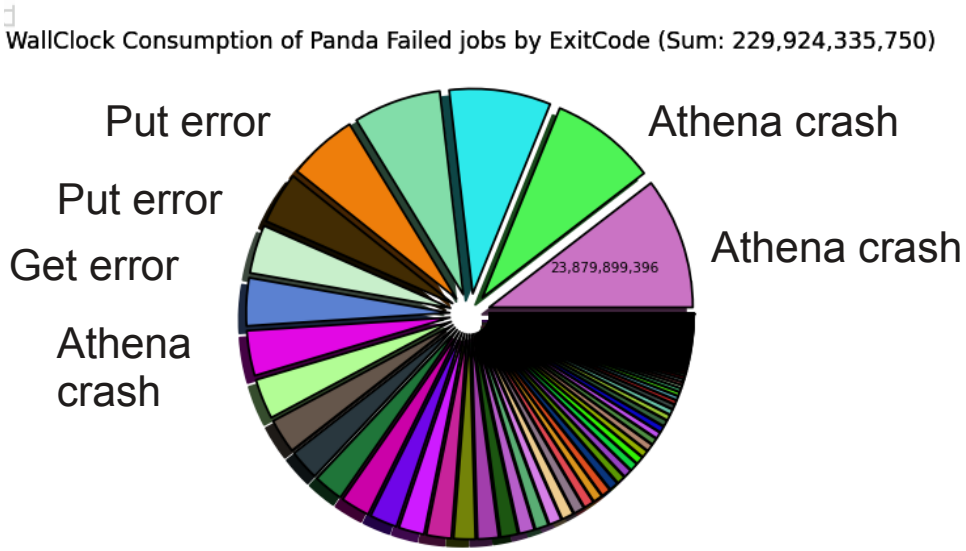
Analysis jobs 2011-2013



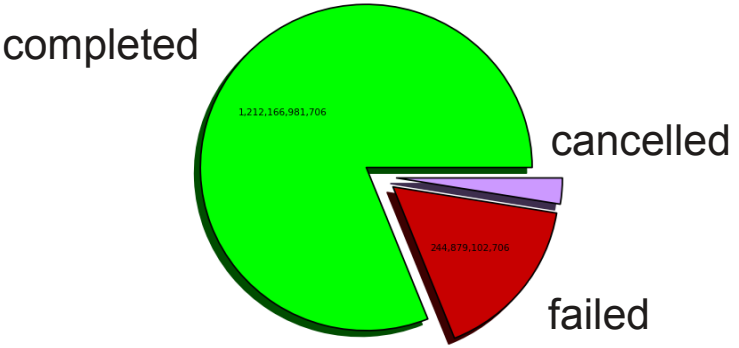
Efficiency analysis jobs: 2011-2013

- Average **400k analysis jobs/day**
- Efficiency : **80%**
- Wall clock consumption of failed jobs: **20%**
- most failures related to user code



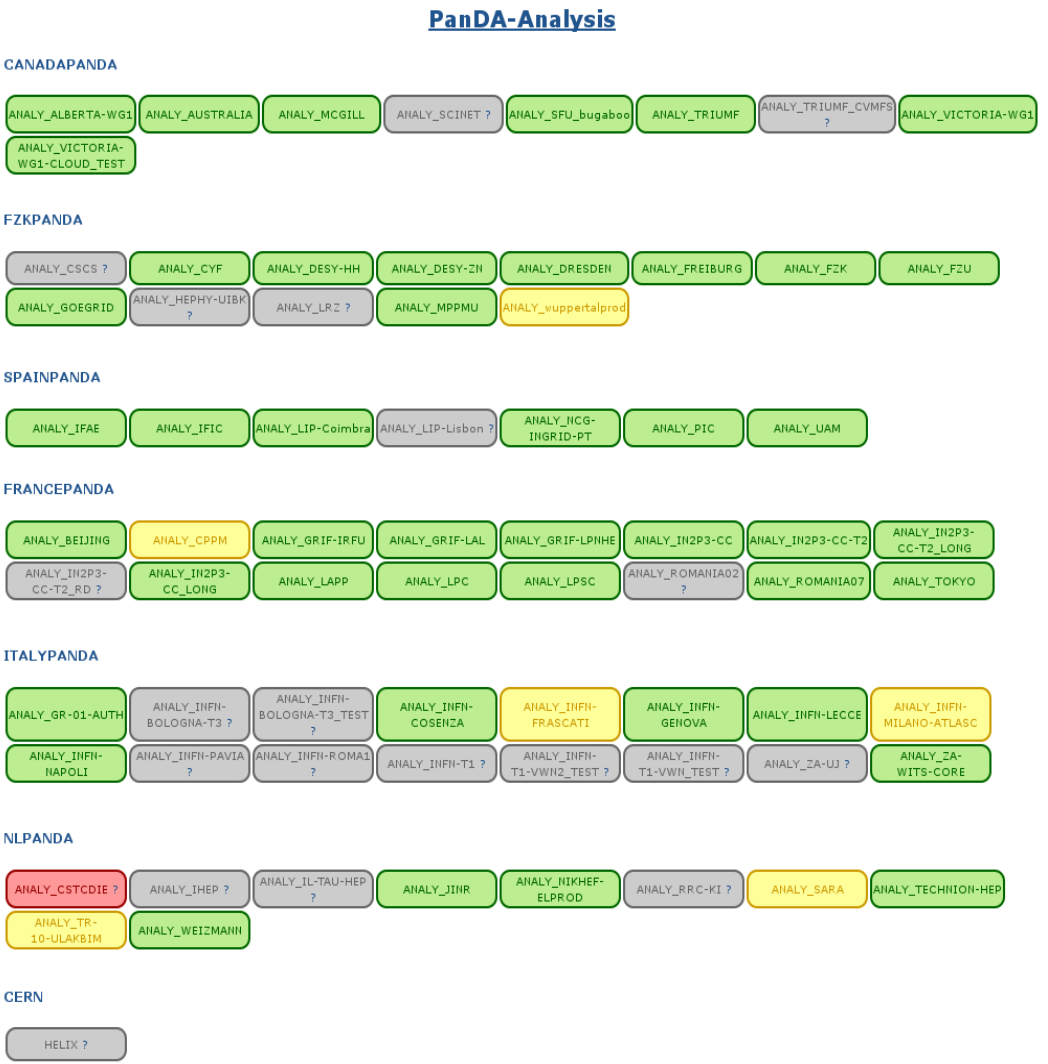


Wall clock consumption



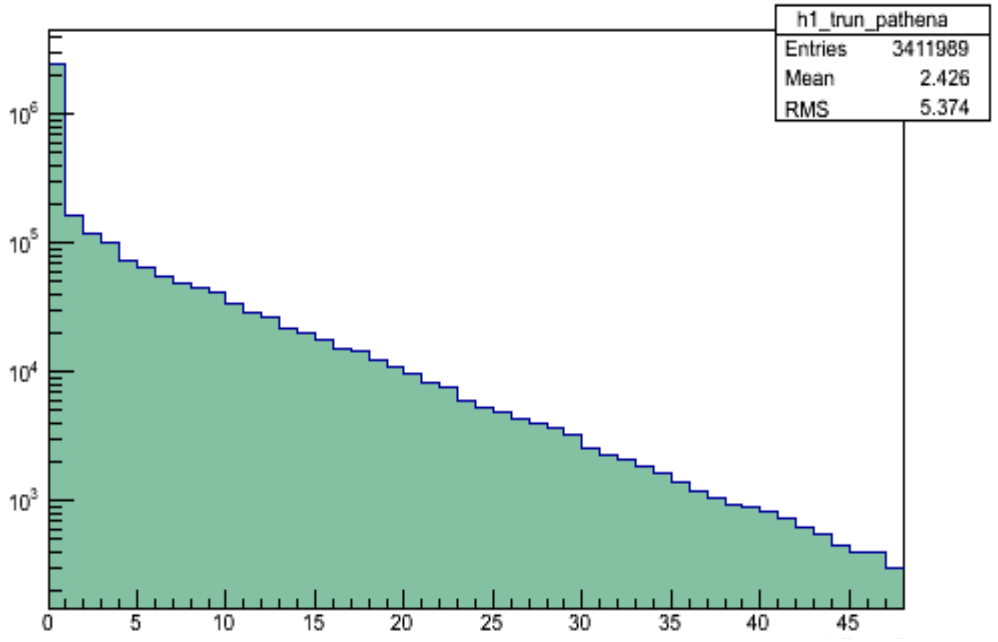
Failed analysis jobs

- What we do to prevent them:
  - Automatic site testing and exclusion from brokerage with **HammerCloud** (see dedicated talk)
  - **DAST** (Distributed Analysis Support Team):
    - User support with dedicated mailing list
    - expert shifters help users 16 hours/day (American and European time-zones)
  - What we plan to do:
    - Better error reporting for automatic retrials/better debugging
    - Automatic kill user jobs in case of massive failures



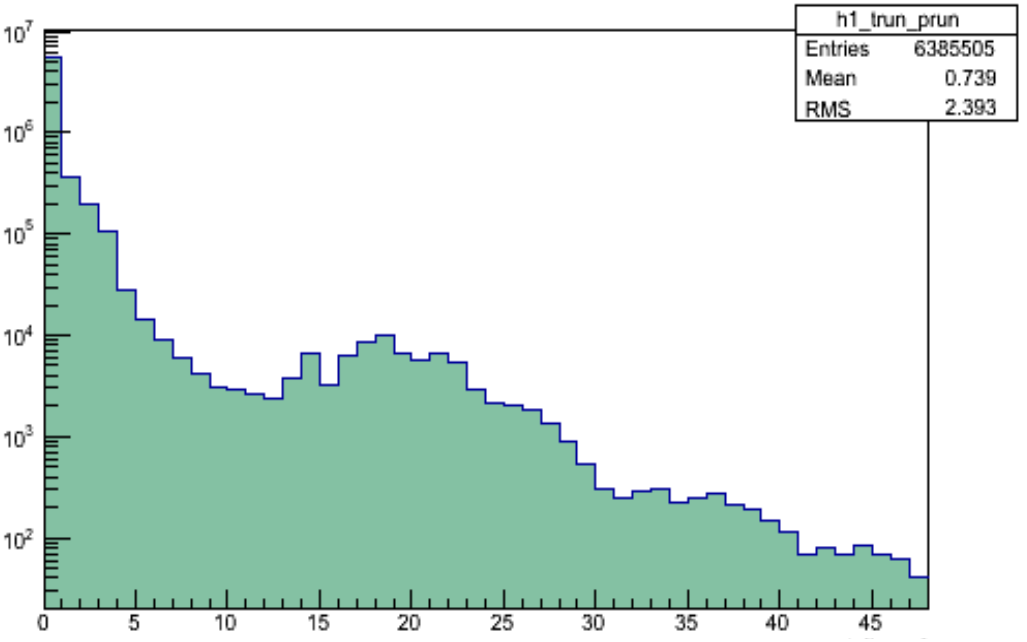
Analysis job length – January 2013

Jobs running on AODs



Run time [hours]

Jobs running on D3PDs



Run time [hours]

Most analysis jobs last 1 hour or less
→ produce many small files
→ also tail of longer jobs

Profit from better optimization of grid resources → need to estimate job parameters

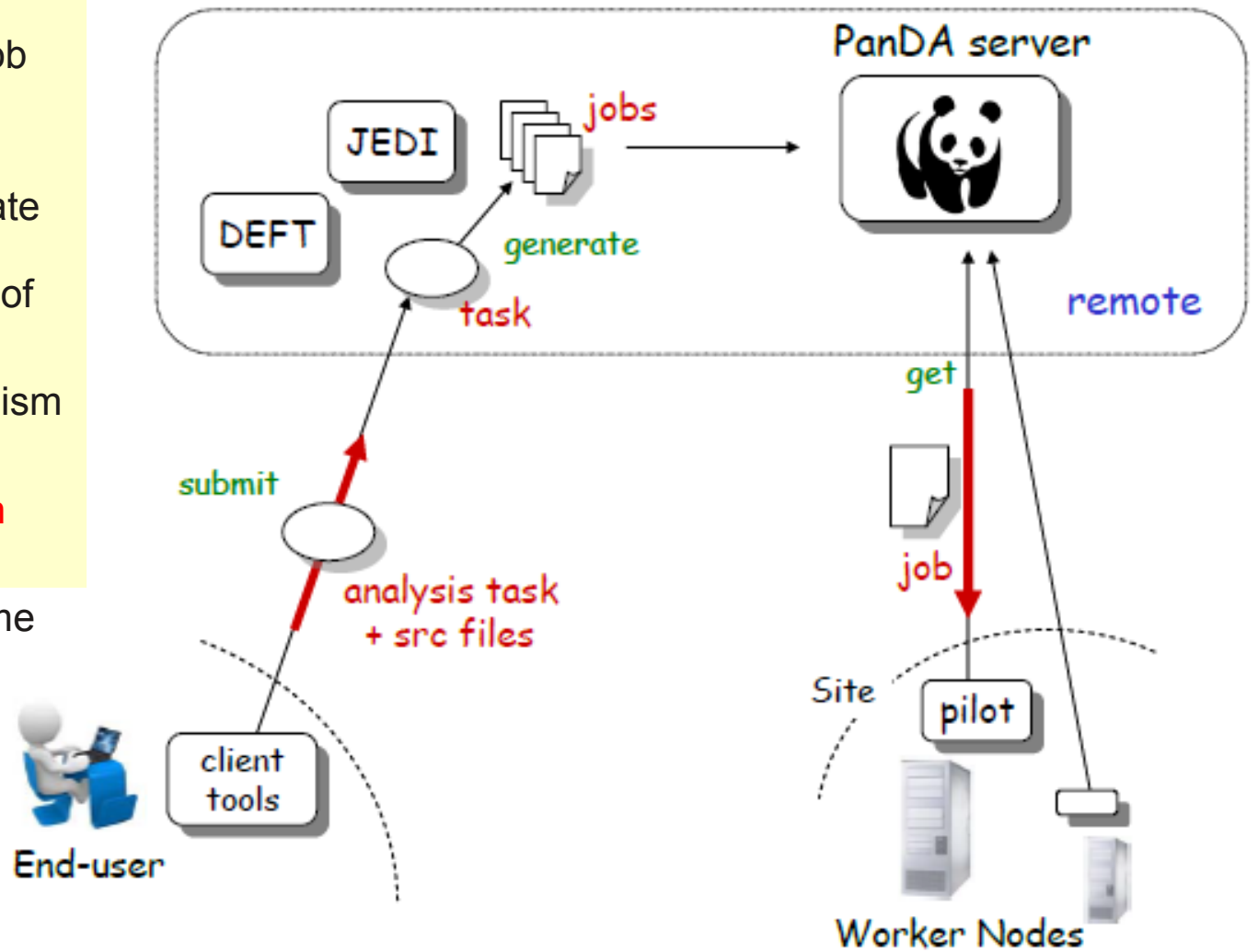
Future Production system

- Based on **tasks** rather than individual **jobs**:
  - More complex work-flows
  - Simplification of client tools:
    - Brokering and task/job management moved **server-side**
    - **Scout jobs** to estimate needed resources → more efficient usage of grid resources
    - Better retrial mechanism for failed jobs
    - faster job submission times!
  - CMS plans to use the same PanDA foundation for analysis

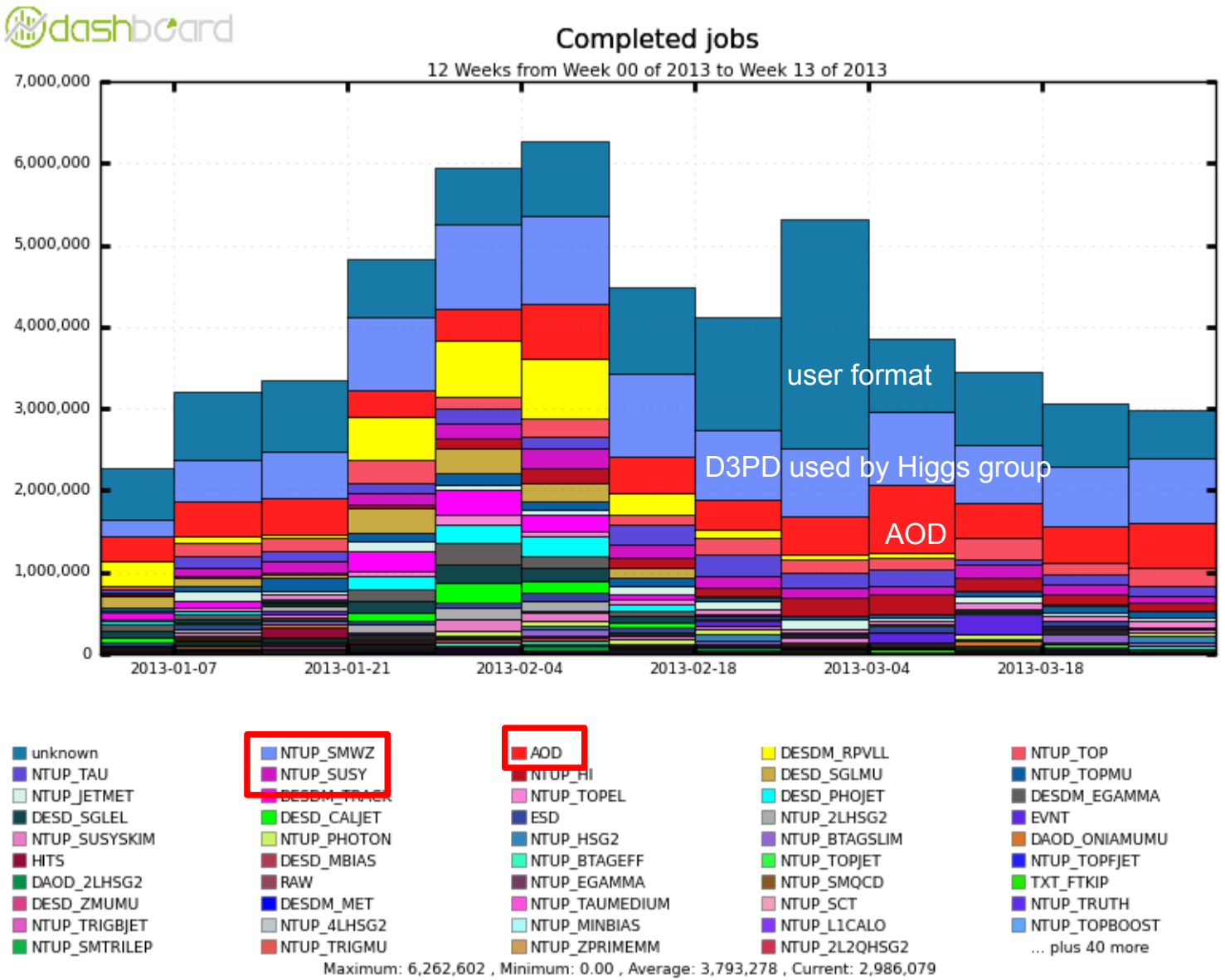
- ProdSys2 (DEFT/JEDI)
- DDM based on Rucio

→ see dedicated talks

New Analysis model



Input data – January-March 2013



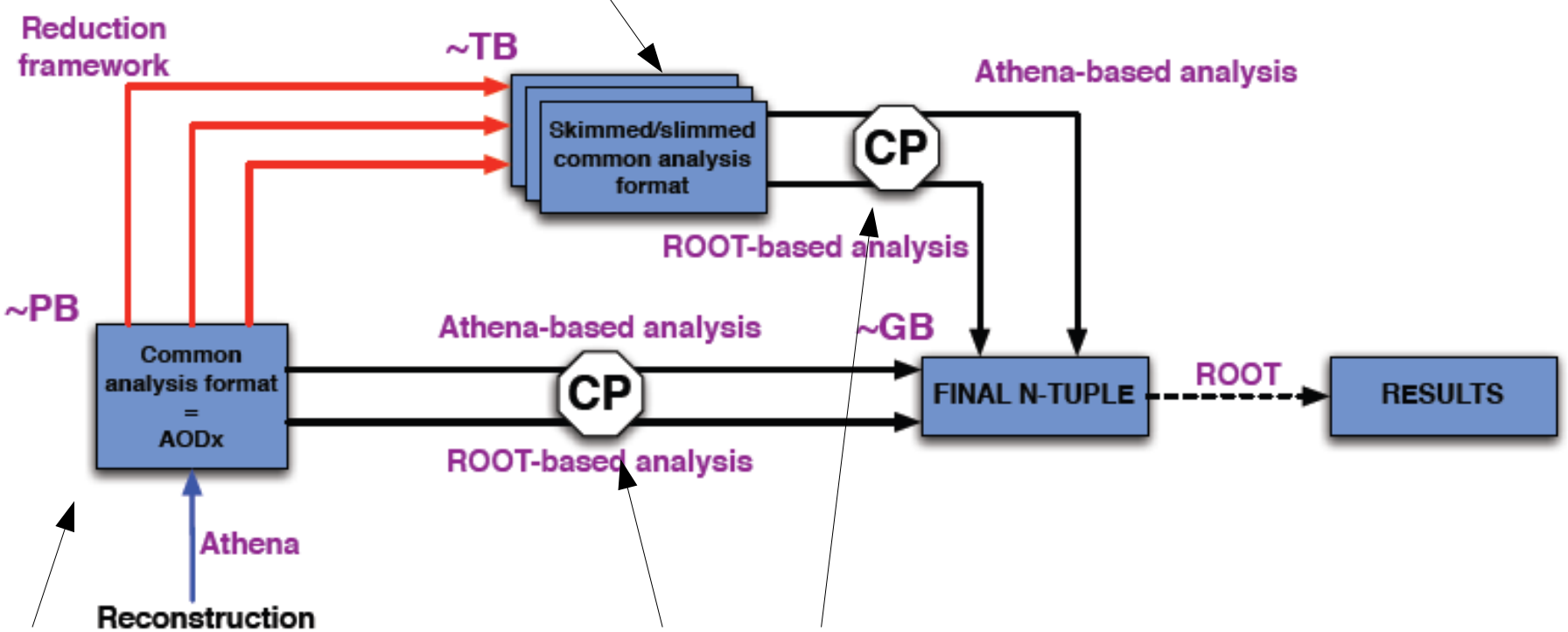
AOD vs D3PD:

- Full reconstruction info *only* available in AOD
- Size D3PD/AOD: up to 50%
- Almost 100 D3PD flavours!
- Total size of a full version of the main D3PDs is 3 times larger than the AODs
- AOD/D3PD users: ¼
- D3PD production: 5-10 s/event, to produce all D3PD flavors, 30 s/event are needed

Future analysis model

Centrally provided
reduction framework
for slimming/skimming

New analysis framework to support both reduced and original AODx analysis, integrated with grid tools



Merged AOD+D3PD format:
AODx, readable with both ROOT and athena

Standardized application of Combined Performance (CP) recommendations

Disk space needed at the end of 2015

Current model: AOD+D3PD New model

	events	MB/evt	AOD (PB)	D3PD (PB)	AODx (PB)
2012, data	$3.9 \cdot 10^9$	0.24	0.9	2.8	1.2
2012, MC	$4.5 \cdot 10^9$	0.40	1.8	5.4	2.2
2015, data	$5 \cdot 10^9$	0.24	2.4	14.4	6
2015, MC	$6 \cdot 10^9$	0.40	4.8	28.8	12

Assumptions:

- AODx / AOD = 1.25, D3PD/AOD = 3
- Total size of run 1 is 2 x size of 2012
- 1 copy of run 1 data
- 2 copies of 2015 data, 2 versions of D3PDs/AODx

	AOD+D3PD (PB)	AODx (PB)
Run 1	22	7
2015	50	18
Total	**72**	**25**

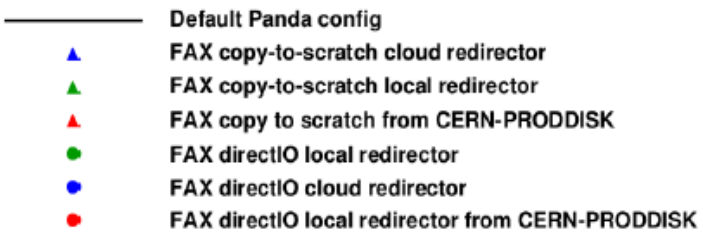
The Federated ATLAS XrootD system (FAX)

- Storage federation aiming to treat Tier1, Tier2 and Tier3 storage space as a *single distributed storage system*

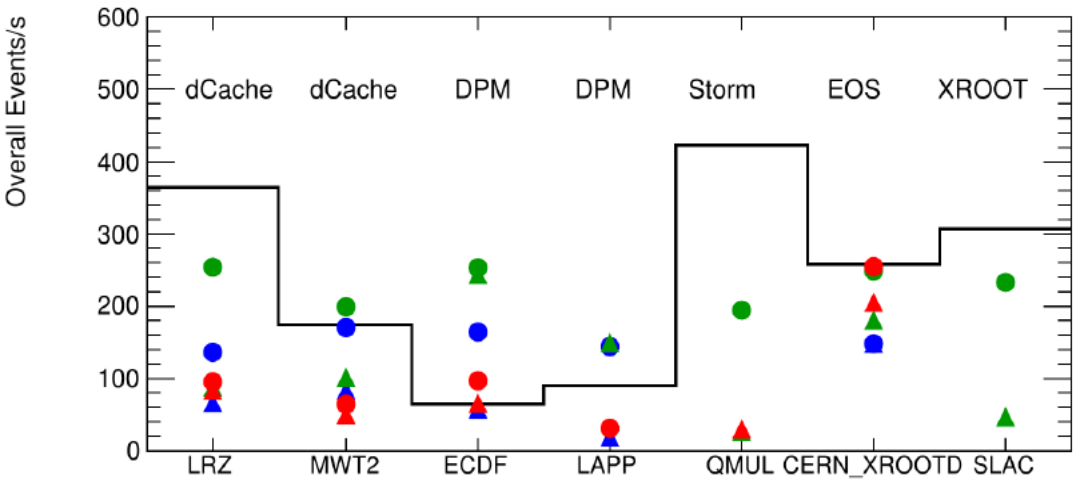
  → relax *data-CPU locality* paradigm

  - **FAX** routes the client to the nearest site with the requested data (scope yet to be defined)
    - data access through a client software like ROOT or xrdcp (other protocols as http under evaluation)
    - requires advanced caching mechanism as TTreeCache
    - transparent for the user
    - currently under evaluation
    - see dedicated talk

Different input access modes:



Result for example sites of different storage systems:



- **Use cases:**
  - Quick scan through large data sample
  - Fetch missing files instead of failed jobs
  - Use of opportunistic resources

Conclusions

- Successful deployment of Distributed Analysis in ATLAS during run 1:
  - 400k/day user jobs: 80% efficiency, 5% grid-related failures (mostly due to storage failure)
  - HammerCloud auto-exclusion to ensure smooth grid operation
  - DAST to provide user support

- Several challenges coming up:
  - new Analysis Model, new Production system, remote file access with FAX

- Future developments:
  - Balance production vs analysis resources, use of opportunistic not ATLAS resources
  - Features to improve user experience:
    - estimate of time-to-completion and improved job monitoring
    - improved automatic job retrial
    - job output to local storage
  - Features to smooth grid operations:
    - Definition of user job limits
    - Monitoring of massive user job failures

Backup

Assumptions disk space calculation

		2012 (8 TeV)	2015 (14 TeV)
Trigger rate	events/s	400 + 150 (delayed)	1000
Data	events	$3 + 1$ (delayed) $\cdot 10^9$	$5 \cdot 10^9$
MC	events	$4.5 \cdot 10^9$	$6 \cdot 10^9$
Raw size	MB/event	0.8	1.1
AOD size (data)	KB/event	250	250
AOD size (MC)	KB/event	400	400
D3PD size (data)	KB/event	50-130	
D3PD size (MC)	KB/event	100-200	