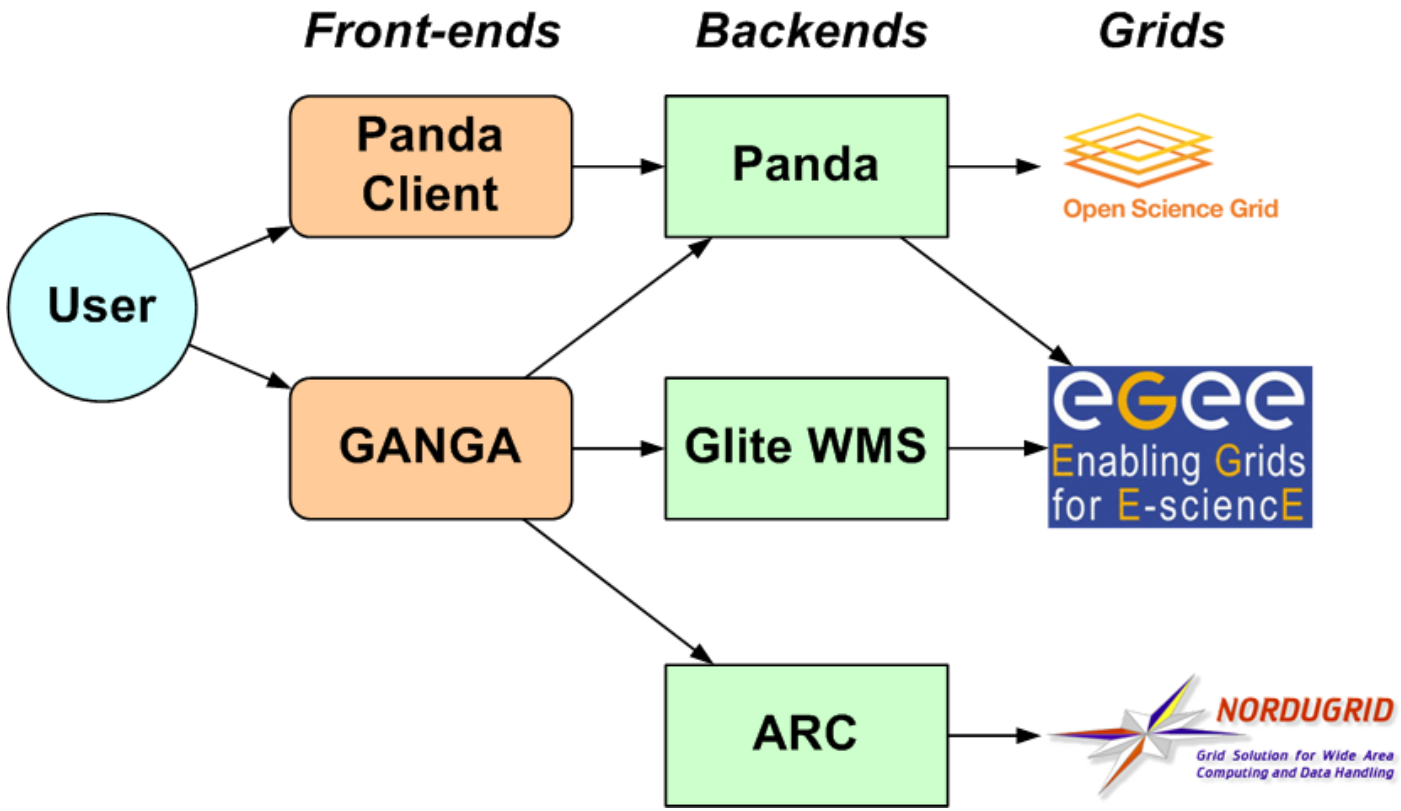
IT Department

# ATLAS Distributed Analysis Experiences in STEP'09

Dan van der Ster
for the DA stress testing team and ATLAS Distributed Computing

*WLCG STEP'09 Post-Mortem*
*10 July 2009*

# Distributed Analysis in ATLAS

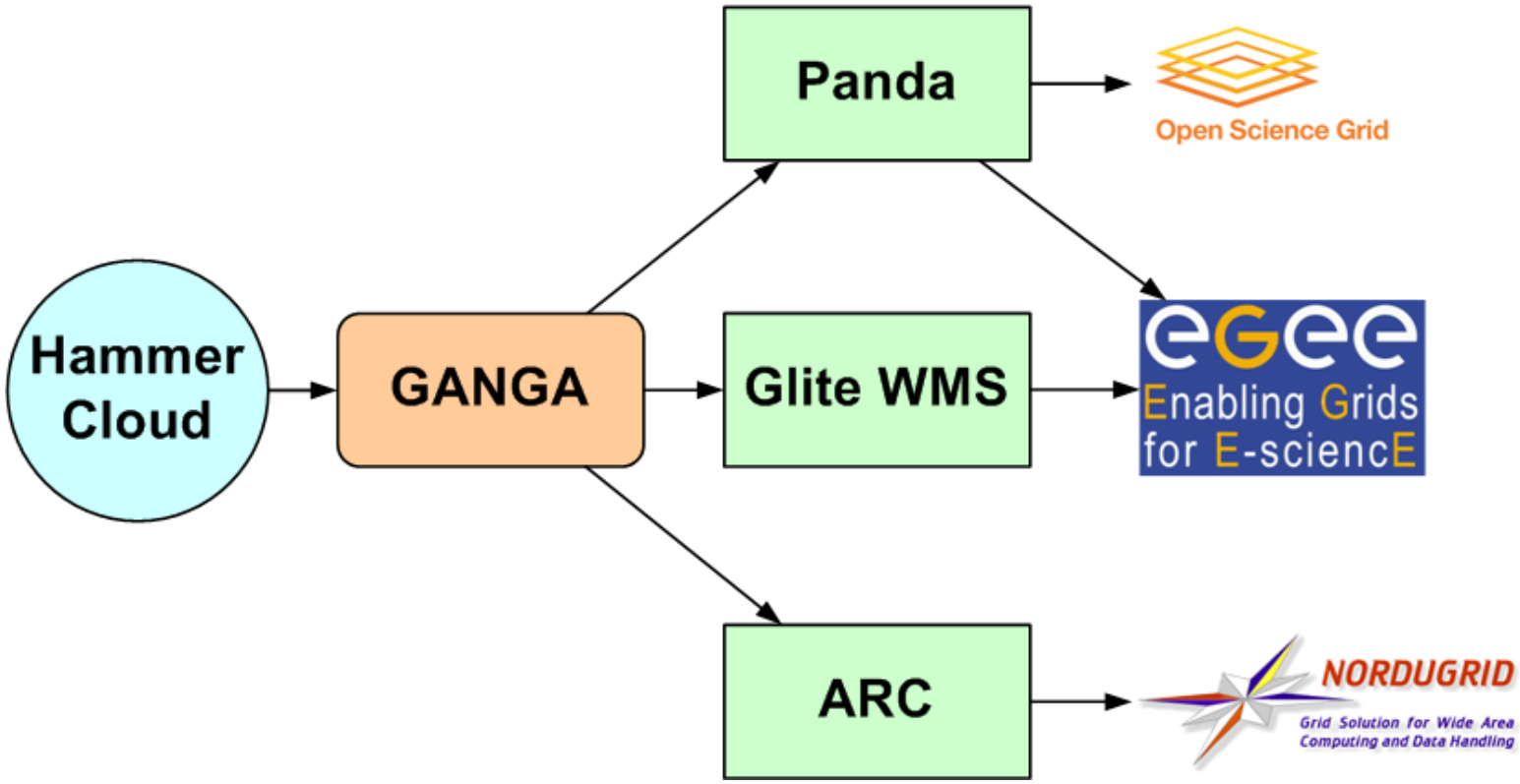



- Classic Athena analyses:
  - various input data sizes: ESD, AOD, DPD
  - TAG for direct event access
- Calibration & Alignment: RAW data and remote DB access
- Private MC production
- everything else (ROOT, arbitrary executables...)

# DA Tests During STEP'09

- Stress testing with HammerCloud
  - "Infinite" real analysis jobs to participating sites (all T2's + a few T1's)
  - Most (~all) of our STEP'09 results drawn from these tests
- Coordinated user activity
  - US and DE challenges
- Background (normal) user activity
  - Some sites were quite busy without HC's help

# HC: Workflows tested

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  - various input data sizes: ESD, **AOD**, DPD
  - TAG for direct event access
- Calibration & Alignment: RAW data and remote DB access
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# HC Testing Details

Four AOD analysis jobs:

WMS: 30GB per job, 2 Local protocol, 2 FileStager

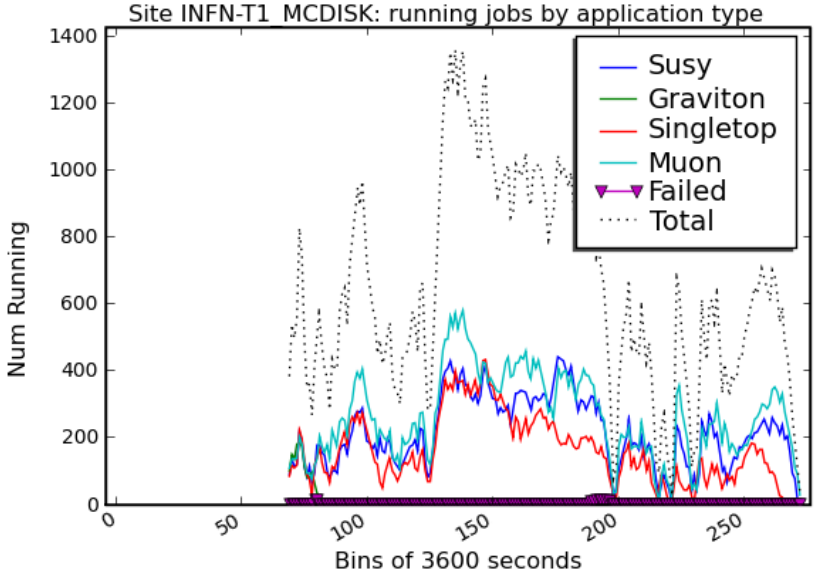
Panda: 5GB per job, switched to 10GB ~Sat.

ARC/NG: 5GB per job

Note: we expect ~4-6 times more Panda jobs than WMS jobs at the shared sites.

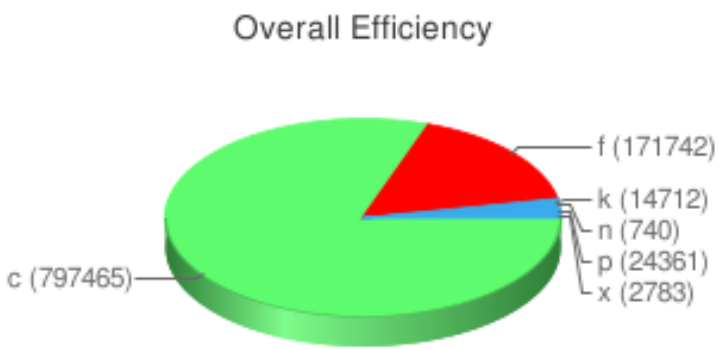
All analyses run at ~15-19Hz with local fast files.

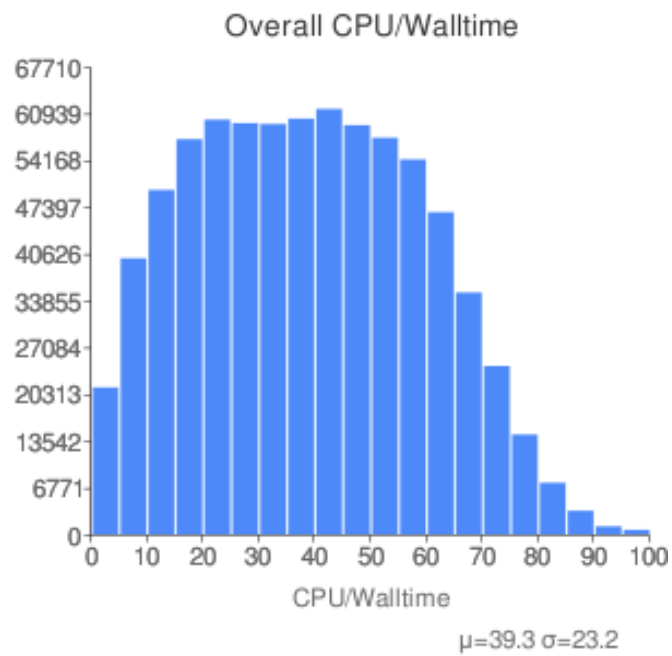
*CNAF running 3-4 analyses throughout STEP09. "Graviton" job (using FS) was turned off at WMS sites because of large log files and memory leak. (F. Galezzi)*

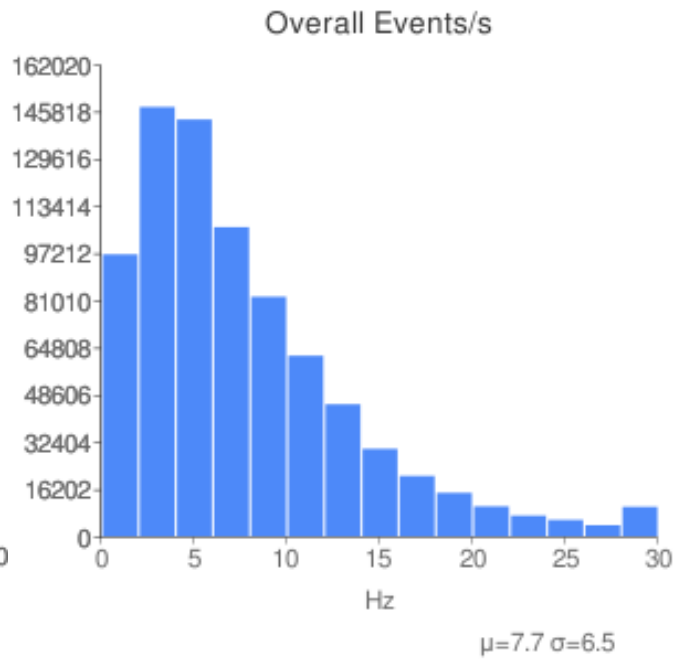


# HC: Global Summary

~1M jobs submitted -- 82.3% succeeded
Total 26.3B events processed
Mean Events/s = 7.7Hz
Mean CPU/Walltime = 0.39




**Global Efficiency: 82.3%** **Global Rate: 28.6kHz**

# Tabulated Results

All the following results are available at:
http://gangarobot.cern.ch/st/step09summary.html

Definitions:

***Efficiency = #completed/(#completed+#failed)***

***Hz = avg(#events/(stoptime-starttime))***
***Note: potential bias between Panda/WMS***

***CPU/Walltime:***
***For gLite: = "Percent of CPU this job got..." as reported by time athena...***
***For Panda: = 100 * cpuConsumptionTime / cpuConversion / (endTime - startTime)***

# Cloud Summary: Throughput

| Cloud | # Jobs | # Successful | # Failed | Efficiency | #files | #events ▲ | Hz | CPU/Wall |
|---|---|---|---|---|---|---|---|---|
| FR | 166427 | 144658 | 21769 | 0.869 | 557571 | 5050911395 | 9.3 | 44.5 |
| DE | 176076 | 135218 | 40858 | 0.768 | 557395 | 4991372555 | 7.9 | 40.8 |
| US | 163004 | 153240 | 9764 | 0.940 | 465393 | 4169999722 | 6.0 | 33.9 |
| UK | 181394 | 145222 | 36172 | 0.801 | 439084 | 3984651767 | 7.1 | 39.8 |
| IT | 59163 | 52990 | 6173 | 0.896 | 311061 | 2798011153 | 6.5 | 32.6 |
| ES | 72562 | 62565 | 9997 | 0.862 | 236690 | 2150478621 | 10.0 | 44.3 |
| NL | 66632 | 37171 | 29461 | 0.558 | 154452 | 1352903529 | 7.9 | 35.0 |
| TW | 24178 | 19544 | 4634 | 0.808 | 86293 | 833817261 | 15.2 | 48.4 |
| CA | 41890 | 32306 | 9584 | 0.771 | 87117 | 757520054 | 4.2 | 34.4 |
| NG | 16730 | 14551 | 2179 | 0.870 | 20179 | 172708698 | 7.3 | |

# Cloud Summary: Efficiency

| Cloud | # Jobs | # Successful | # Failed | Efficiency ▲ | #files | #events | Hz | CPU/Wall |
|---|---|---|---|---|---|---|---|---|
| US | 163004 | 153240 | 9764 | 0.940 | 465393 | 4169999722 | 6.0 | 33.9 |
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| CA | 41890 | 32306 | 9584 | 0.771 | 87117 | 757520054 | 4.2 | 34.4 |
| DE | 176076 | 135218 | 40858 | 0.768 | 557395 | 4991372555 | 7.9 | 40.8 |
| NL | 66632 | 37171 | 29461 | 0.558 | 154452 | 1352903529 | 7.9 | 35.0 |

# Site Summaries

We now look at the site performance.

The metric used to rank the sites is debatable.

I will present sites ordered by normalized throughput:
Millions of events processed / AOD data share

Sites with share < 0.1 have been filtered out for now
Complete tables are in the "backup" slides.

My interpretation of the metric:
If you perform well it means:
(a) you performed well
(b) your data share is too small
(c) both
If you do not perform well it means:
(a) you have an excuse e.g. many background user jobs
(b) you did not perform well

# Site Summary (1)

| Cloud | Site | # Jobs | Eff. | evts | share | Size(TB) | evts/share ▾ | Hz | CPU/W |
|---|---|---|---|---|---|---|---|---|---|
| ES | PIC | 41117 | 0.948 | 1177 | 0.10 | 64.0 | 11776 | 10.8 | 46.3 |
| FR | IN2P3-LAPP | 33661 | 0.970 | 1233 | 0.15 | 64.0 | 8222 | 11.7 | 53.4 |
| DE | CSCS-LCG2 | 29541 | 0.918 | 970 | 0.17 | 70.0 | 5707 | 6.7 | 43.1 |
| UK | UKI-SCOTGRID-GLASGOW | 78327 | 0.974 | 1846 | 0.40 | 148.0 | 4615 | 8.4 | 42.6 |
| DE | GOEGRID | 13798 | 0.776 | 673 | 0.15 | 76.0 | 4488 | 5.7 | 26.0 |
| NL | RU-PROTVINO-IHEP | 14690 | 0.896 | 550 | 0.15 | 60.0 | 3667 | 11.2 | 38.6 |
| ES | LIP-LISBON | 10172 | 0.545 | 320 | 0.10 | 77.0 | 3205 | 11.4 | 39.7 |
| FR | BEIJING-LCG2 | 13211 | 0.846 | 318 | 0.10 | 54.0 | 3189 | 8.0 | 51.2 |
| FR | IN2P3-LPC | 12857 | 0.913 | 468 | 0.15 | 84.0 | 3123 | 7.2 | 47.1 |
| US | NET2 | 29906 | 0.954 | 960 | 0.33 | 117.0 | 2909 | 6.6 | 32.9 |
| US | MWT2 | 35195 | 0.968 | 1051 | 0.40 | 481.0 | 2628 | 6.7 | 37.9 |
| FR | GRIF-LAL | 22070 | 0.826 | 613 | 0.24 | 105.0 | 2555 | 9.8 | 42.6 |
| US | AGLT2 | 64325 | 0.954 | 1528 | 0.60 | 358.0 | 2547 | 6.0 | 27.1 |
| UK | UKI-NORTHGRID-LIV-HEP | 10717 | 0.831 | 349 | 0.15 | 81.0 | 2328 | 5.9 | 50.2 |
| DE | CYFRONET-LCG2 | 24271 | 0.696 | 386 | 0.17 | 99.0 | 2274 | 7.4 | 32.7 |
| DE | DESY-ZN | 26759 | 0.977 | 1115 | 0.50 | 157.0 | 2231 | 11.3 | 56.7 |
| UK | UKI-LT2-RHUL | 30258 | 0.702 | 505 | 0.23 | 185.0 | 2196 | 6.2 | 36.8 |
| IT | INFN-T1 | 32878 | 0.908 | 1886 | 1.00 | -1.0 | 1886 | 6.5 | 33.2 |

Great normalized throughput. But check your efficiency and event rate.

# Site Summary (2)

| Cloud | Site | # Jobs | Eff. | evts | share | Size(TB) | evts/share ▲ | Hz | CPU/W |
|---|---|---|---|---|---|---|---|---|---|
| IT | INFN-NAPOLI-ATLAS | 12899 | 0.949 | 527 | 0.30 | 156.0 | 1757 | 7.5 | 37.2 |
| DE | LRZ-LMU | 15814 | 0.711 | 278 | 0.16 | 146.0 | 1740 | 8.7 | 40.1 |
| DE | MPPMU | 10641 | 0.553 | 270 | 0.16 | 89.0 | 1689 | 6.8 | 34.6 |
| UK | UKI-SOUTHGRID-RALPP | 9565 | 0.862 | 418 | 0.25 | 76.0 | 1675 | 4.5 | 24.3 |
| ES | UAM-LCG2 | 10179 | 0.888 | 393 | 0.25 | 126.0 | 1572 | 8.7 | 46.1 |
| TW | TW-FTT | 19085 | 0.803 | 756 | 0.50 | 115.0 | 1512 | 17.6 | 49.6 |
| FR | TOKYO-LCG2 | 36470 | 0.986 | 1501 | 1.00 | 293.0 | 1501 | 11.0 | 46.6 |
| DE | DESY-HH | 18723 | 0.942 | 681 | 0.50 | 180.0 | 1362 | 9.3 | 43.9 |
| NL | TR-10-ULAKBIM | 8616 | 0.866 | 230 | 0.20 | 80.0 | 1153 | 4.1 | 32.5 |
| NL | JINR-LCG2 | 11110 | 0.468 | 221 | 0.20 | 63.0 | 1107 | 8.6 | 29.1 |
| UK | UKI-NORTHGRID-SHEF-HEP | 6227 | 0.821 | 102 | 0.10 | 36.0 | 1020 | 6.6 | 50.7 |
| US | SLACXRD | 14716 | 0.889 | 337 | 0.34 | 215.0 | 993 | 4.0 | 64.8 |
| IT | INFN-ROMA1 | 7848 | 0.864 | 270 | 0.30 | 131.0 | 901 | 6.3 | 25.6 |
| FR | GRIF-SACLAY | 8672 | 0.935 | 213 | 0.26 | 63.0 | 822 | 8.9 | 45.2 |
| DE | UNI-FREIBURG | 8805 | 0.604 | 126 | 0.17 | 106.0 | 743 | 7.7 | 45.5 |
| CA | ALBERTA-LCG2 | 5370 | 0.884 | 185 | 0.25 | 24.0 | 740 | 4.8 | 28.3 |
| IT | INFN-FRASCATI | 2748 | 0.877 | 71 | 0.10 | 38.0 | 715 | 4.3 | 29.5 |
| ES | IFAE | 7588 | 0.928 | 161 | 0.25 | 68.0 | 647 | 5.7 | 29.7 |
| UK | UKI-NORTHGRID-MAN-HEP1 | 7948 | 0.633 | 83 | 0.15 | 40.0 | 559 | 3.8 | 45.8 |

Good normalized throughput. Again, check efficiency and event rate.

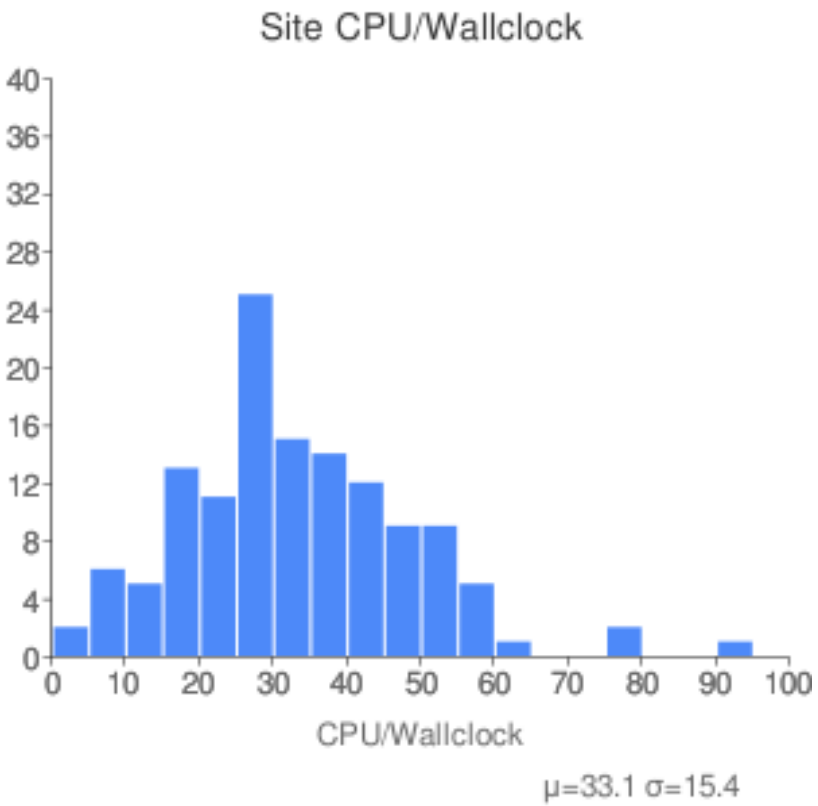
# Site Summary (3)

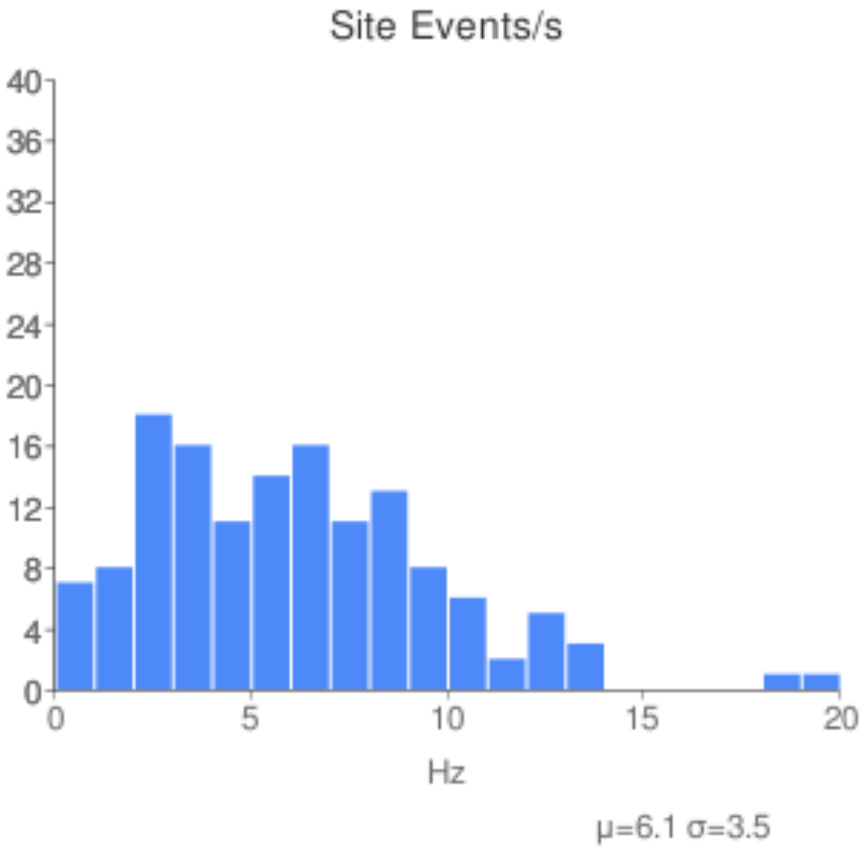
| Cloud | Site | # Jobs | Eff. | evts | share | Size(TB) | evts/share ▲ | Hz | CPU/W |
|---|---|---|---|---|---|---|---|---|---|
| UK | UKI-NORTHGRID-MAN-HEP2 | 9347 | 0.382 | 71 | 0.15 | 40.0 | 479 | 2.8 | 32.0 |
| FR | GRIF-LPNHE | 10312 | 0.857 | 217 | 0.50 | 140.0 | 435 | 7.9 | 34.2 |
| DE | FZK-LCG2 | 16286 | 0.681 | 424 | 1.00 | -1.0 | 424 | 4.1 | 23.0 |
| US | SWT2 | 8053 | 0.788 | 134 | 0.33 | 40.0 | 406 | 2.0 | 16.7 |
| CA | SFU-LCG2 | 10832 | 0.950 | 270 | 0.72 | 157.0 | 375 | 5.8 | 26.6 |
| FR | RO-02-NIPNE | 2810 | 0.432 | 37 | 0.10 | 51.0 | 373 | 2.9 | 19.2 |
| ES | IFIC-LCG2 | 2372 | 0.753 | 87 | 0.25 | 68.0 | 350 | 12.4 | 63.8 |
| NL | ITEP | 864 | 0.991 | 34 | 0.10 | 10.0 | 347 | 7.5 | 38.5 |
| UK | UKI-NORTHGRID-LANCS-HEP | 6819 | 0.565 | 78 | 0.30 | 140.0 | 260 | 4.8 | 24.5 |
| FR | IN2P3-CC | 10486 | 0.761 | 212 | 1.00 | -1.0 | 212 | 3.1 | 26.7 |
| DE | HEPHY-UIBK | 2056 | 0.467 | 19 | 0.10 | 36.0 | 193 | 4.5 | 19.5 |
| NG | NDGF-T1 | 16730 | 0.870 | 172 | 1.00 | -1.0 | 172 | 7.3 | |
| US | BNL-OSG2 | 10809 | 0.911 | 157 | 1.00 | -1.0 | 157 | 7.1 | 34.5 |
| NL | NIKHEF-ELPROD | 5174 | 0.875 | 143 | 1.00 | -1.0 | 143 | 7.5 | 39.6 |
| IT | INFN-MILANO | 2790 | 0.612 | 42 | 0.30 | 78.0 | 140 | 1.7 | 19.2 |
| TW | AUSTRALIA-ATLAS | 4548 | 0.891 | 67 | 0.50 | 119.0 | 135 | 6.0 | 42.4 |
| NL | RRC-KI | 5339 | 0.402 | 67 | 0.50 | 171.0 | 135 | 2.9 | 18.3 |
| DE | WUPPERTALPROD | 5783 | 0.210 | 19 | 0.17 | 63.0 | 117 | 4.7 | 29.7 |
| FR | RO-07-NIPNE | 1516 | 0.157 | 5 | 0.10 | 33.0 | 59 | 5.7 | 27.0 |
| NL | SARA-MATRIX | 1461 | 0.763 | 41 | 1.00 | -1.0 | 41 | 3.3 | 37.2 |
| UK | UKI-LT2-UCL-CENTRAL | 473 | 0.222 | 3 | 0.10 | 16.0 | 35 | 3.8 | 28.3 |
| NL | RU-PNPI | 204 | 0.632 | 4 | 0.15 | 65.0 | 28 | 0.8 | 11.1 |
| ES | LIP-COIMBRA | 1134 | 0.160 | 9 | 0.50 | 115.0 | 19 | 6.4 | 22.1 |
| TW | TAIWAN-LCG2 | 545 | 0.321 | 9 | 1.00 | 125.0 | 9 | 13.2 | 94.2 |

Low throughput

Reasons:
- Many other jobs
- Low efficiency
- Low event rates
- ... ?

# Performance




~All sites have I/O bottleneck

*Mean rate is ~1/3rd your laptop*

# A Note on Efficiencies

We have always recorded the *success efficiency* , but probably more interesting would be the *time-weighted efficiency* :

*time-weighted eff = time spent in successful jobs / total time*

note that **success eff == time eff** *iff* mean(succ. time) == mean(fail time)

During STEP09:

mean successful Panda job took 4584 s.
mean failed Panda job took 5721 s.
overall completion efficiency for Panda was 0.856
overall time efficiency was 0.827

for WMS we didn't record the times for failed jobs, but with hanging posix I/O connections failing jobs could waste *a lot* of time.

**In future we should focus on the time-weighted efficiency metric to better understand how the sites are being utilized.**

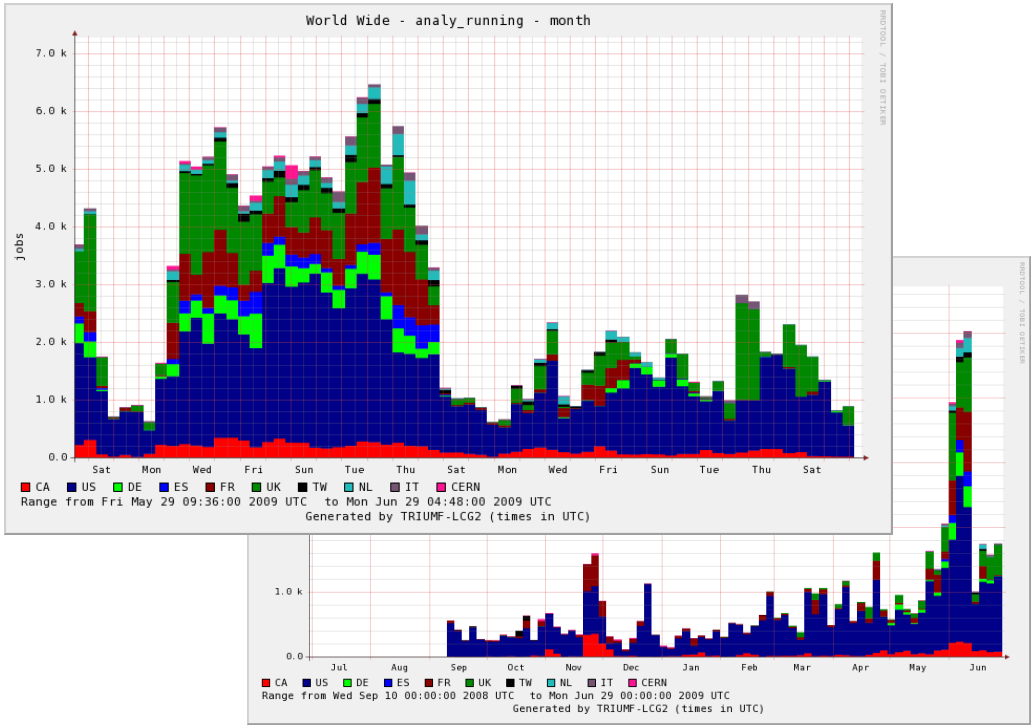
# PanDA Results

Panda uses "copy mode" at most sites.

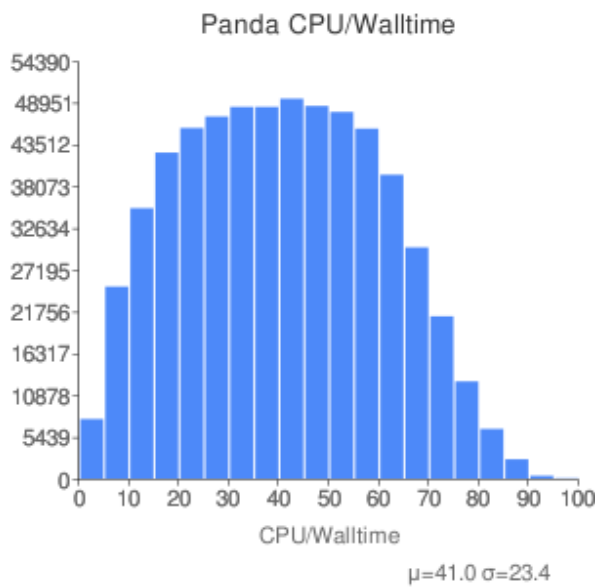
Record job numbers for Panda DA: peaked at ~6500 concurrent

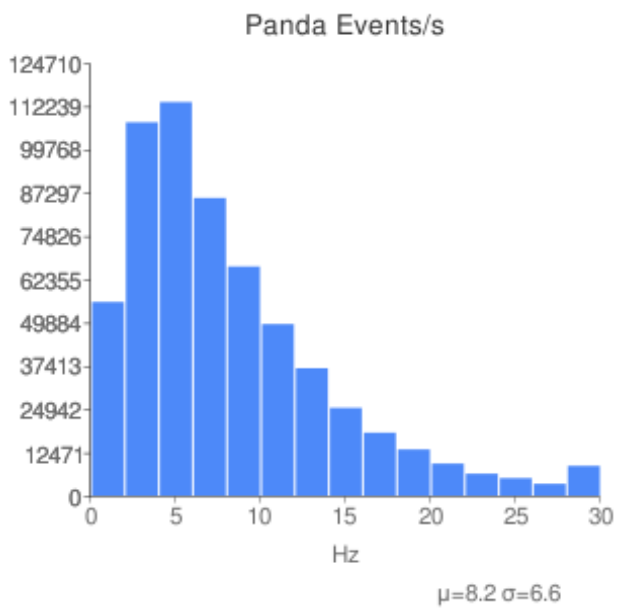
84.9% success efficiency

Slightly above average CPU/wall and Hz







# Panda Analysis Conclusions

1. Pilots:
   DE, IT didn't run enough Panda jobs, probably queue depth was not large enough

**Need to better organize the pilot factories**

2. Data access timeouts:
   40% of the failures were "Get error: lcg-cp get was timed out after 1800 seconds"

**Need a way to discover terminally ill vs. slow transfers**

3."Hidden failures" at xrootd sites. (athena didn't read all events)
   *10% errors at LYON, 2% at SLAC, and 1.4% at SWT2_CPB*

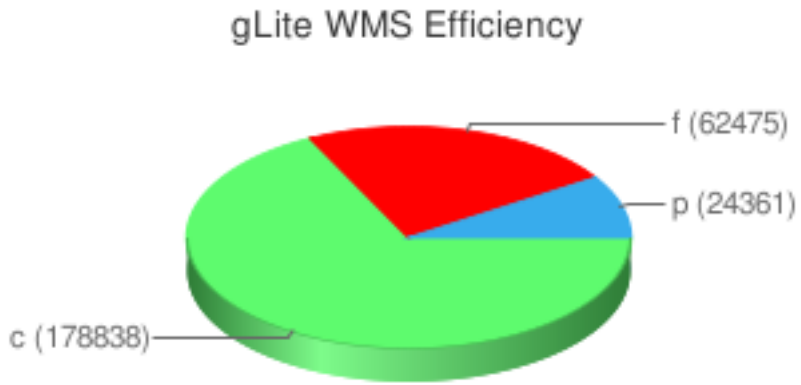
**Need reliable run report from athena, and post job validation**

# gLite WMS Results

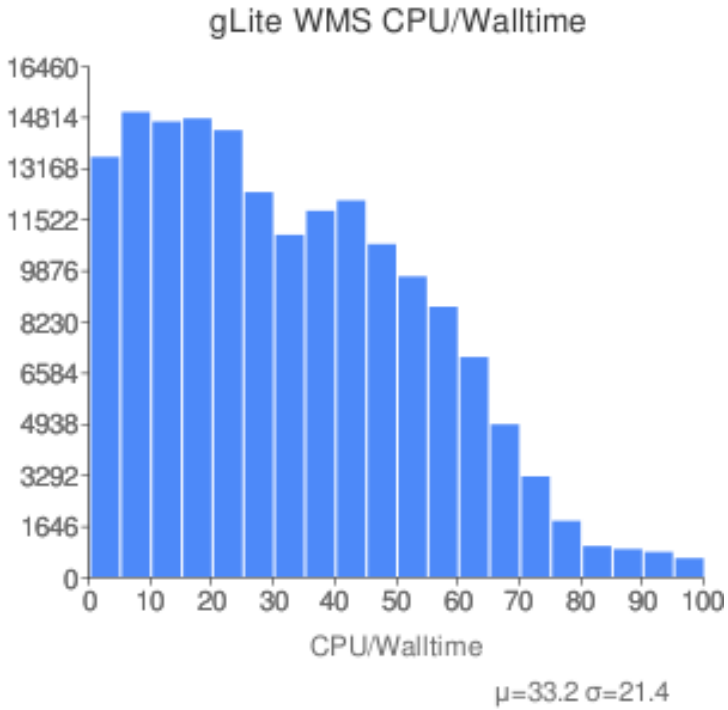
WMS jobs used mostly posix I/O:

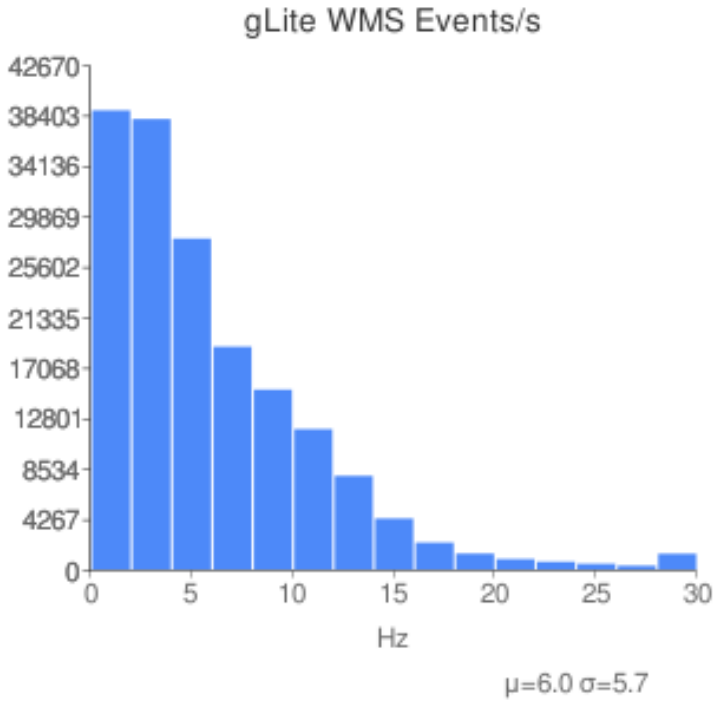
For WMS analysis we have been more *adventurous* ...
FileStager "copy" mode was not used as much as
we had intended.

*74% success efficiency*
*below avg. Hz and CPU/Wall*




Lower WMS efficiency results from long jobs higher susceptibility to I/O flakiness and poor posix I/O performance



# gLite WMS issues

1. Longer jobs lead to more failures with memory leaks, huge log files, etc...

**Clients should default to fine & intelligent splitting**

2. Ganga-MonAlisa link was down so we couldn't easily track the WMS jobs

**Need more reliable central monitoring of the WMS jobs**

3. Post analysis is difficult. Need to download log files and parse:

**Post process on WN. Adopt error codes from Panda.**

4. On average Posix I/O did not perform well. This is the default for WMS jobs, so we should change it.

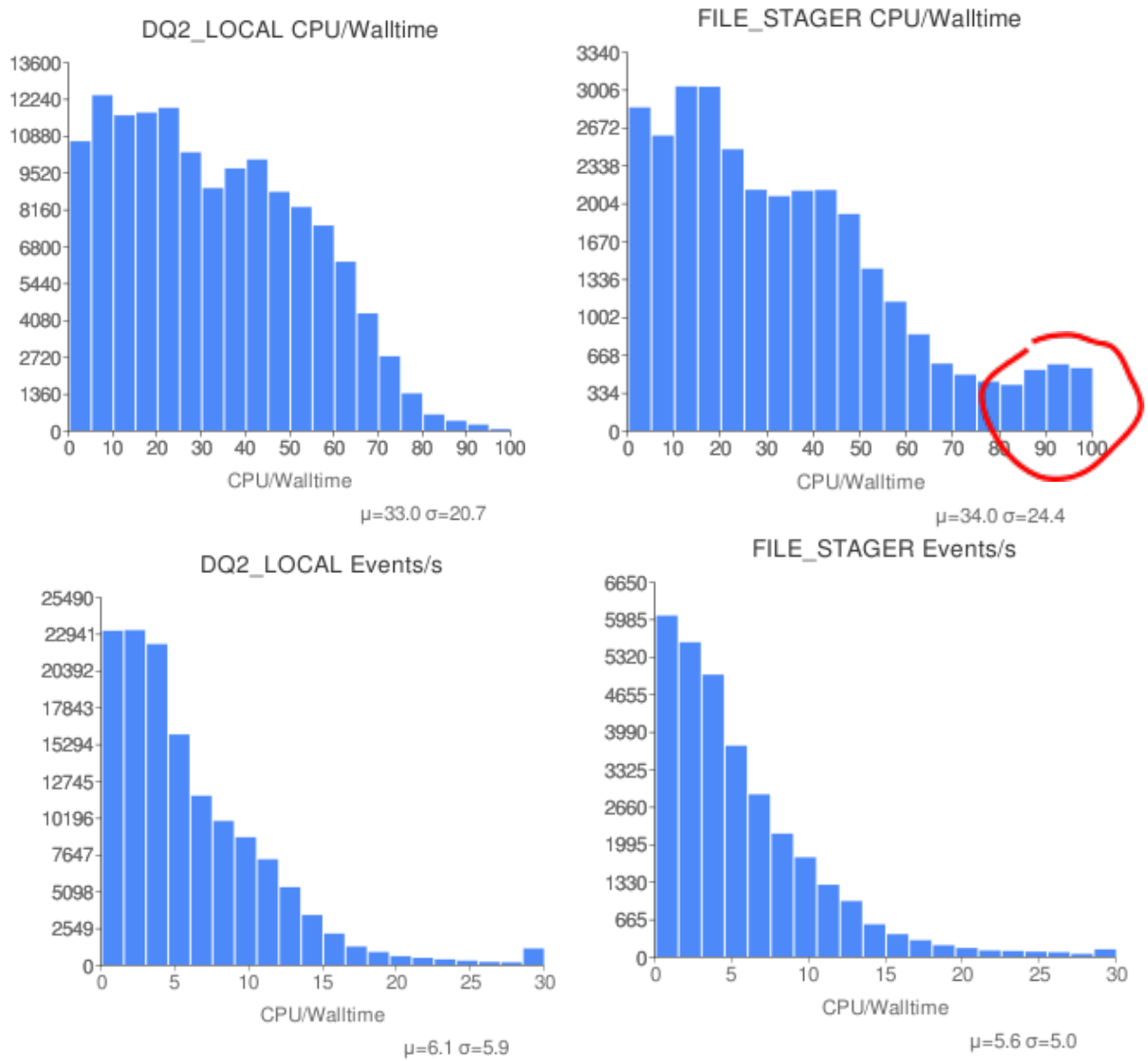
**Data access method should be same for Panda and WMS jobs, not user definable, and stored in central IS (it is already in Panda DB)**

# Data Access Methods

The "WMS" tests were mostly direct I/O.

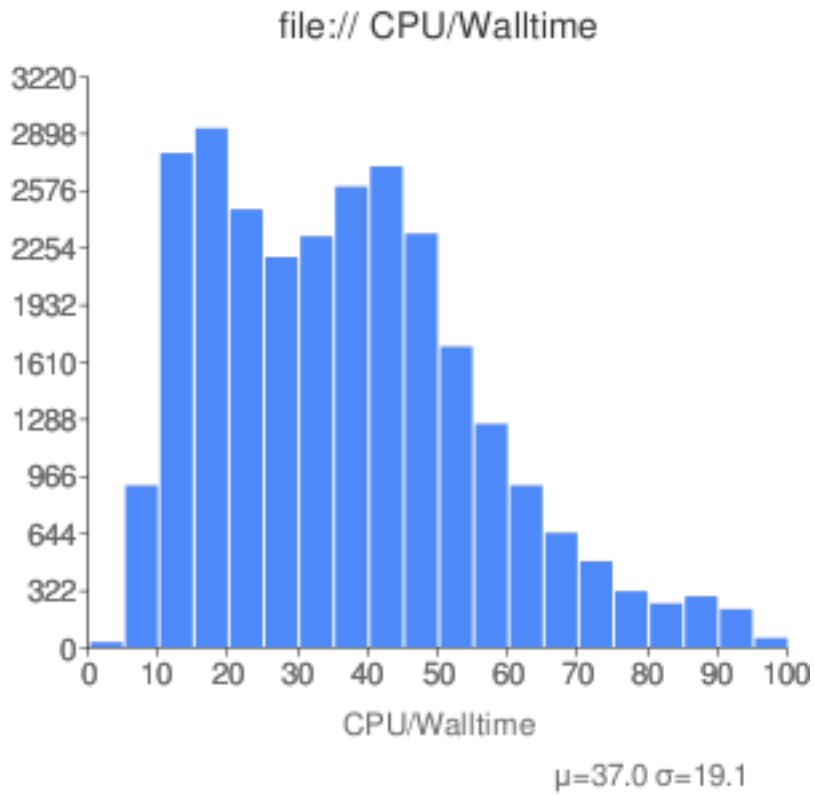
By chance the 2 FS analyses were memory leaky and produced huge log files so we stopped these early.

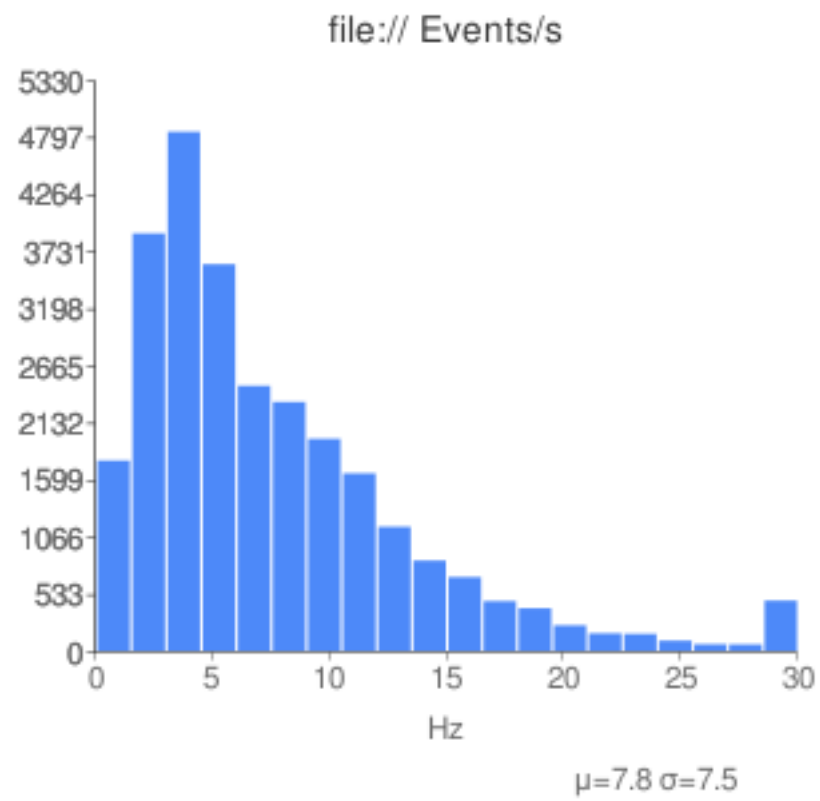
In previous tests FS vastly outperformed direct access at most sites; here it did not. Apparently, the usage of direct access at a site penalized the FS jobs running at the same site.




**Should move to FileStager where beneficial and possible.**

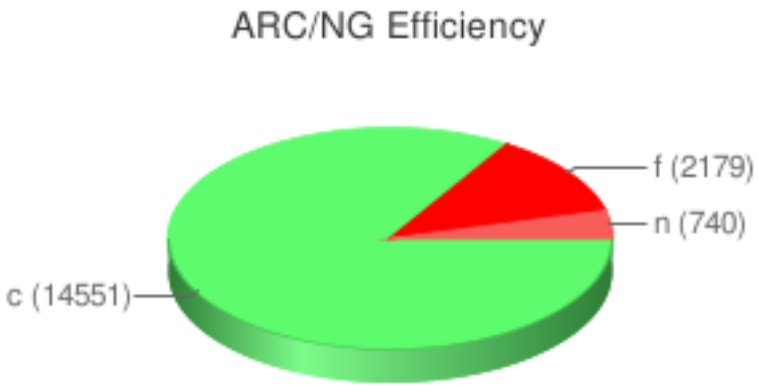
# file:// protocol at CNAF, IFIC, LIP




Better than dcap/rfio and FileStager:
- only a few very slow jobs
- still the storage is the bottleneck

# ARC/NG Results




Efficiency was high, but middleware issues led to low throughput at the sites (due to data stage-in delay to the site caches). Solutions are in development.

**More stress testing is needed at NG sites**

# Real User Analysis During STEP'09

There was *a lot* of real analysis during STEP'09.

Coordinated efforts in US and DE (that I have results from).

**US**: 14 users processed a 1M evt sample (for 75M total events processed with ~75% efficiency)

Job success efficiency (%)

| AGLT2 | MWT2 | NET2 | SLAC | SWT2 |
|---|---|---|---|---|
| 59* | 80 | 74 | 84 | 75 |

* one user made many attempts here before overcoming user config issue

- from slides of J. Cochran

# Coordinated Analysis in DE

| User | Site/Cloud | N-Job fail | N-Job succe | Efficiency | N-Files | N-Evts | Wall-time | evt rate Hz | Cpu/Wall |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | |
| | DE | 223 | 1335 | 85.69 | 6675 | 12894675 | 21815080 | 0.59 | 0.26 |
| | FR | 115 | 0 | 0 | | | | | |
| 2 | | | | | | | | | |
| | DE | 8162 | 8046 | 49.64 | 10515 | 73986440 | 50649545 | 1.46 | 0.43 |
| | UK | 0 | 85 | 100 | 848 | 211493 | 207363 | 1.02 | 0.43 |
| | FR | 329 | 219 | 39.96 | 2137 | 533588 | 404915 | 1.32 | 0.4 |
| | IT | 61 | 222 | 78.45 | 2210 | 551024 | 256054 | 2.15 | 0.71 |
| | US | 770 | | | | | | | |
| 3 | | | | | | | | | |
| | DE | 0 | 158 | 100 | 158 | 964496 | 84730 | 11.38 | 0.76 |
| 4 | | | | | | | | | |
| | DE | 22 | 1630 | 98.67 | 1630 | 1630000 | 239599 | 6.8 | 0.49 |

19.06.09 1 Günter Duckeck, LMU

Results from 4 users:

~90M events varied efficiencies

# Background User Analysis

We know that real analysis continued behind HC, but exact numbers aren't known worldwide (because of WMS monitoring lapse).

In US we know:

- 426309 user analysis jobs during STEP'09
- 173648 (~40%) from HC
- Remaining 60% from 198 other users
  - 172k succeeded, 80k failed (of which 40-50k killed by user)

*- numbers from K. De.*

In general, looking at the overall efficiency of real user jobs is almost meaningless

- need to perform detailed error analysis to identify site/service vs. user errors, which is possible but onerous with existing tools.

# Distributed Analysis User Support

- DA user support is provided by the DAST shifters.
  - 1 EU + 1 US shift per week
- Made no special preparations for STEP'09
  - i.e. normal shift rotation without extra effort
- The numbers:
  - 2-12 June (STEP'09) saw 76 threads in the DA help forum
    - No extraordinary problems or complaints
  - Pre STEP (22 May - 1 June): 73 threads
  - Post STEP (13-23 June):76 threads

- The user support model succeeded during STEP'09, though we are still planning to increase the shifter effort to handle the influx of users coming with real data.

# Conclusions

- The distributed analysis tests during STEP'09 were a success for ATLAS:
  - The services were exercised at record levels.
  - Global Efficiency: 82.3%  Global Rate: 28.6kHz
  - Real users continued to get real work done

- The problems are known...
  - dcap/rfio access is troublesome at heavy load
  - our pilot factories need to be better organized
  - need better communication with athena
  - monitoring can be improved (as always)
  - and others.
- ...but most have known solutions.

- Testing continues now... no waiting for SEPT

# Backup: all sites (1)

| Cloud | Site | # Jobs | Eff. | evts | share | Size(TB) | evts/share ▾ | Hz | CPU/W |
|---|---|---|---|---|---|---|---|---|---|
| CA | VICTORIA-LCG2 | 7941 | 0.775 | 193 | 0.01 | 35.5 | 19333 | 4.1 | 39.7 |
| UK | UKI-SOUTHGRID-OX-HEP | 4420 | 0.871 | 269 | 0.02 | 66.0 | 13455 | 4.4 | 21.7 |
| ES | PIC | 41117 | 0.948 | 1177 | 0.10 | 64.0 | 11776 | 10.8 | 46.3 |
| FR | IN2P3-LAPP | 33661 | 0.970 | 1233 | 0.15 | 64.0 | 8222 | 11.7 | 53.4 |
| DE | CSCS-LCG2 | 29541 | 0.918 | 970 | 0.17 | 70.0 | 5707 | 6.7 | 43.1 |
| CA | TORONTO-LCG2 | 17747 | 0.626 | 108 | 0.02 | 20.0 | 5439 | 2.5 | 41.5 |
| UK | UKI-SCOTGRID-GLASGOW | 78327 | 0.974 | 1846 | 0.40 | 148.0 | 4615 | 8.4 | 42.6 |
| DE | GOEGRID | 13798 | 0.776 | 673 | 0.15 | 76.0 | 4488 | 5.7 | 26.0 |
| NL | RU-PROTVINO-IHEP | 14690 | 0.896 | 550 | 0.15 | 60.0 | 3667 | 11.2 | 38.6 |
| ES | LIP-LISBON | 10172 | 0.545 | 320 | 0.10 | 77.0 | 3205 | 11.4 | 39.7 |
| FR | BEIJING-LCG2 | 13211 | 0.846 | 318 | 0.10 | 54.0 | 3189 | 8.0 | 51.2 |
| FR | IN2P3-LPC | 12857 | 0.913 | 468 | 0.15 | 84.0 | 3123 | 7.2 | 47.1 |
| FR | IN2P3-CPPM | 12143 | 0.573 | 154 | 0.05 | 26.0 | 3091 | 4.7 | 24.3 |
| US | NET2 | 29906 | 0.954 | 960 | 0.33 | 117.0 | 2909 | 6.6 | 32.9 |
| UK | UKI-SOUTHGRID-CAM-HEP | 5050 | 0.708 | 143 | 0.05 | 32.0 | 2864 | 8.4 | 33.7 |
| US | MWT2 | 35195 | 0.968 | 1051 | 0.40 | 481.0 | 2628 | 6.7 | 37.9 |
| FR | GRIF-LAL | 22070 | 0.826 | 613 | 0.24 | 105.0 | 2555 | 9.8 | 42.6 |
| US | AGLT2 | 64325 | 0.954 | 1528 | 0.60 | 358.0 | 2547 | 6.0 | 27.1 |
| UK | UKI-NORTHGRID-LIV-HEP | 10717 | 0.831 | 349 | 0.15 | 81.0 | 2328 | 5.9 | 50.2 |
| DE | CYFRONET-LCG2 | 24271 | 0.696 | 386 | 0.17 | 99.0 | 2274 | 7.4 | 32.7 |
| DE | DESY-ZN | 26759 | 0.977 | 1115 | 0.50 | 157.0 | 2231 | 11.3 | 56.7 |
| UK | UKI-LT2-RHUL | 30258 | 0.702 | 505 | 0.23 | 185.0 | 2196 | 6.2 | 36.8 |
| IT | INFN-T1 | 32878 | 0.908 | 1886 | 1.00 | -1.0 | 1886 | 6.5 | 33.2 |

# Backup: all sites (2)

| Cloud | Site | # Jobs | Eff. | evts | share | Size(TB) | evts/share ▲ | Hz | CPU/W |
|---|---|---|---|---|---|---|---|---|---|
| IT | INFN-NAPOLI-ATLAS | 12899 | 0.949 | 527 | 0.30 | 156.0 | 1757 | 7.5 | 37.2 |
| DE | LRZ-LMU | 15814 | 0.711 | 278 | 0.16 | 146.0 | 1740 | 8.7 | 40.1 |
| DE | MPPMU | 10641 | 0.553 | 270 | 0.16 | 89.0 | 1689 | 6.8 | 34.6 |
| UK | UKI-SOUTHGRID-RALPP | 9565 | 0.862 | 418 | 0.25 | 76.0 | 1675 | 4.5 | 24.3 |
| ES | UAM-LCG2 | 10179 | 0.888 | 393 | 0.25 | 126.0 | 1572 | 8.7 | 46.1 |
| TW | TW-FTT | 19085 | 0.803 | 756 | 0.50 | 115.0 | 1512 | 17.6 | 49.6 |
| FR | TOKYO-LCG2 | 36470 | 0.986 | 1501 | 1.00 | 293.0 | 1501 | 11.0 | 46.6 |
| FR | IN2P3-LPSC | 2219 | 0.723 | 73 | 0.05 | 29.0 | 1463 | 5.8 | 21.6 |
| UK | UKI-SOUTHGRID-BHAM-HEP | 3249 | 0.948 | 72 | 0.05 | 35.0 | 1440 | 9.7 | 32.9 |
| DE | DESY-HH | 18723 | 0.942 | 681 | 0.50 | 180.0 | 1362 | 9.3 | 43.9 |
| NL | TR-10-ULAKBIM | 8616 | 0.866 | 230 | 0.20 | 80.0 | 1153 | 4.1 | 32.5 |
| NL | JINR-LCG2 | 11110 | 0.468 | 221 | 0.20 | 63.0 | 1107 | 8.6 | 29.1 |
| UK | UKI-NORTHGRID-SHEF-HEP | 6227 | 0.821 | 102 | 0.10 | 36.0 | 1020 | 6.6 | 50.7 |
| US | SLACXRD | 14716 | 0.889 | 337 | 0.34 | 215.0 | 993 | 4.0 | 64.8 |
| IT | INFN-ROMA1 | 7848 | 0.864 | 270 | 0.30 | 131.0 | 901 | 6.3 | 25.6 |
| NL | WEIZMANN-LCG2 | 17806 | 0.115 | 41 | 0.05 | 115.0 | 830 | 7.7 | 38.4 |
| FR | GRIF-SACLAY | 8672 | 0.935 | 213 | 0.26 | 63.0 | 822 | 8.9 | 45.2 |
| UK | UKI-LT2-QMUL | 8440 | 0.276 | 39 | 0.05 | 123.0 | 797 | 3.7 | 29.4 |
| DE | UNI-FREIBURG | 8805 | 0.604 | 126 | 0.17 | 106.0 | 743 | 7.7 | 45.5 |
| CA | ALBERTA-LCG2 | 5370 | 0.884 | 185 | 0.25 | 24.0 | 740 | 4.8 | 28.3 |
| IT | INFN-FRASCATI | 2748 | 0.877 | 71 | 0.10 | 38.0 | 715 | 4.3 | 29.5 |
| ES | IFAE | 7588 | 0.928 | 161 | 0.25 | 68.0 | 647 | 5.7 | 29.7 |
| UK | UKI-NORTHGRID-MAN-HEP1 | 7948 | 0.633 | 83 | 0.15 | 40.0 | 559 | 3.8 | 45.8 |

# Backup: all sites (3)

| Cloud | Site | # Jobs | Eff. | evts | share | Size(TB) | evts/share ▲ | Hz | CPU/W |
|---|---|---|---|---|---|---|---|---|---|
| UK | UKI-NORTHGRID-MAN-HEP2 | 9347 | 0.382 | 71 | 0.15 | 40.0 | 479 | 2.8 | 32.0 |
| FR | GRIF-LPNHE | 10312 | 0.857 | 217 | 0.50 | 140.0 | 435 | 7.9 | 34.2 |
| DE | FZK-LCG2 | 16286 | 0.681 | 424 | 1.00 | -1.0 | 424 | 4.1 | 23.0 |
| US | SWT2 | 8053 | 0.788 | 134 | 0.33 | 40.0 | 406 | 2.0 | 16.7 |
| CA | SFU-LCG2 | 10832 | 0.950 | 270 | 0.72 | 157.0 | 375 | 5.8 | 26.6 |
| FR | RO-02-NIPNE | 2810 | 0.432 | 37 | 0.10 | 51.0 | 373 | 2.9 | 19.2 |
| ES | IFIC-LCG2 | 2372 | 0.753 | 87 | 0.25 | 68.0 | 350 | 12.4 | 63.8 |
| NL | ITEP | 864 | 0.991 | 34 | 0.10 | 10.0 | 347 | 7.5 | 38.5 |
| NL | CSTCDIE | 1368 | 0.379 | 16 | 0.05 | 39.0 | 331 | 7.3 | 35.4 |
| UK | UKI-NORTHGRID-LANCS-HEP | 6819 | 0.565 | 78 | 0.30 | 140.0 | 260 | 4.8 | 24.5 |
| FR | IN2P3-CC | 10486 | 0.761 | 212 | 1.00 | -1.0 | 212 | 3.1 | 26.7 |
| DE | HEPHY-UIBK | 2056 | 0.467 | 19 | 0.10 | 36.0 | 193 | 4.5 | 19.5 |
| NG | NDGF-T1 | 16730 | 0.870 | 172 | 1.00 | -1.0 | 172 | 7.3 | |
| US | BNL-OSG2 | 10809 | 0.911 | 157 | 1.00 | -1.0 | 157 | 7.1 | 34.5 |
| NL | NIKHEF-ELPROD | 5174 | 0.875 | 143 | 1.00 | -1.0 | 143 | 7.5 | 39.6 |
| IT | INFN-MILANO | 2790 | 0.612 | 42 | 0.30 | 78.0 | 140 | 1.7 | 19.2 |
| NL | RRC-KI | 5339 | 0.402 | 67 | 0.50 | 171.0 | 135 | 2.9 | 18.3 |
| TW | AUSTRALIA-ATLAS | 4548 | 0.891 | 67 | 0.50 | 119.0 | 135 | 6.0 | 42.4 |
| DE | WUPPERTALPROD | 5783 | 0.210 | 19 | 0.17 | 63.0 | 117 | 4.7 | 29.7 |
| DE | PRAGUELCG2 | 870 | 0.294 | 3 | 0.05 | 23.0 | 65 | 0.7 | 8.9 |
| FR | RO-07-NIPNE | 1516 | 0.157 | 5 | 0.10 | 33.0 | 59 | 5.7 | 27.0 |
| NL | SARA-MATRIX | 1461 | 0.763 | 41 | 1.00 | -1.0 | 41 | 3.3 | 37.2 |
| UK | UKI-LT2-UCL-CENTRAL | 473 | 0.222 | 3 | 0.10 | 16.0 | 35 | 3.8 | 28.3 |
| NL | RU-PNPI | 204 | 0.632 | 4 | 0.15 | 65.0 | 28 | 0.8 | 11.1 |
| ES | LIP-COIMBRA | 1134 | 0.160 | 9 | 0.50 | 115.0 | 19 | 6.4 | 22.1 |