# Large scale MC simulation in Helix Nebula commercial cloud

C. Cordeiro, A. Di Girolamo, L. Field, L. Villazon

D. Giordano

(CERN IT-SDC)

# Helix Nebula: Public & Private Partnership



**Strategic Plan**

- Establish multi-tenant, multi-provider cloud infrastructure
- Identify and adopt policies for trust, security and privacy
- Create governance structure
- Define funding schemes

To support the computing capacity needs for the LHC experiments

Setting up a new service to simplify analysis of large genomes, for a deeper insight into evolution and biodiversity

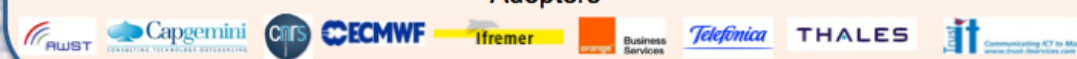To create an Earth Observation platform, focusing on earthquake and volcano research

To improve the speed and quality of research for finding surrogate biomarkers based on brain images
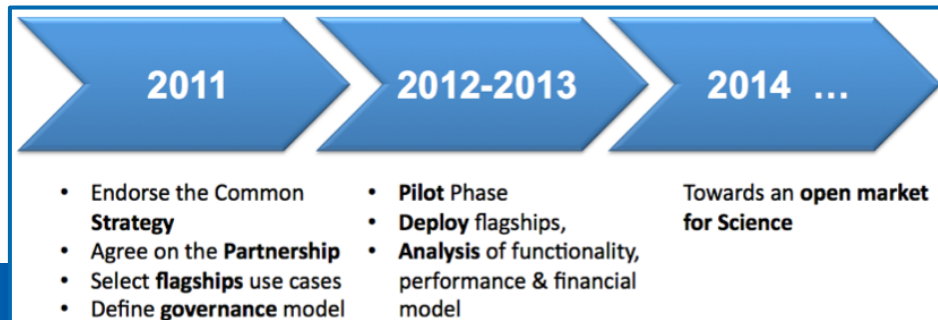
**Suppliers**

Atos CGI CloudSigma CSA cloud security alliance DANTE www.dante.net EGI indra interoute from the ground to the cloud MEMSET HOSTING

SAP sixsq SWITCH T··Systems terradue 20 the SERVER LABS the IT architects ultimum technologies Yandex

**Adopters**

AWST Capgemini cnrs ECMWF Ifremer orange Business Services Telefónica THALES Trust-IT Communicating ICT to Markets

**Project phases**

| 2011 | 2012-2013 | 2014 … |
|------|-----------|--------|
| • Endorse the Common **Strategy** <br> • Agree on the **Partnership** <br> • Select **flagships** use cases <br> • Define **governance** model | • **Pilot** Phase <br> • **Deploy** flagships, <br> • **Analysis** of functionality, performance & financial model | Towards an **open market for Science** |

# Monte Carlo production in HN: Milestones

- Nov. 2014 CERN <u>price enquiry</u>
  - Up to 2,000 VMs for 45 days (from mid Feb. to end March)
    - VM specs: 1 vCPU, 2 GB memory, 20 GB free HD, public IP.     OS: CentOS6
    - Run ATLAS Geant4 Simulation: high CPU/wall time jobs, reduced I/O
  - Atos made best offer. Successful bid confirmed early Jan 2015

- <u>Preparation phase</u> to get the IaaS ready
  - Network: acquire enough IP addresses and configure network
  - Storage: configure NetApp mapping to volumes and storage LUNs, tune # of vFiler images to cope with ISCSI protocol specs
  - Hypervisor: balance KVM load, speed up LUNs' scanning
  - Brokerage: improve robustness and fault tolerance

- <u>Production phase</u> (March 3$^{rd}$ to 31$^{st}$ )
  - Resources available: **200 KVM, 16 cores** each
  - Capacity acquired: started with ~2,000 running VMs, reached 3,000 VMs
  - Several improvements introduced during the production phase
    - **auto-scaling**, revised **provisioning approach, reduced** operational overhead

# Provisioning & monitoring chain
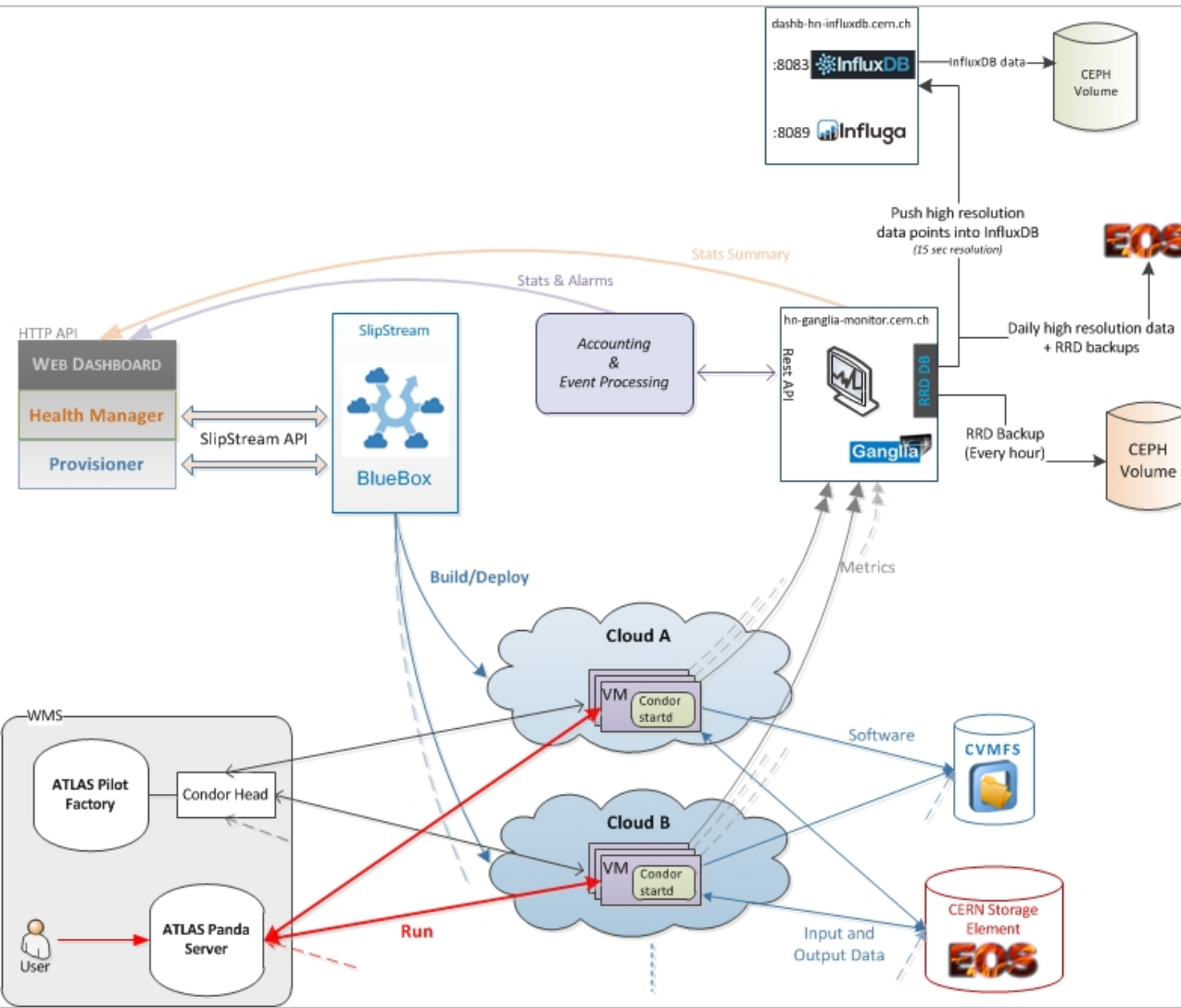


- VM management agent
  - Define, achieve, maintain needed capacity

- WMS
  - Dedicated PanDA resource: HELIX_NEBULA_ATOS
  - APF: aipanda02/09/13

- Key role of VM monitoring
  - Real-time monitoring
  - Alarming
  - Accounting
  - Benchmarking

- Strategy
  - Ganglia data preserved with 15s time resolution
  - Benchmark each VM at startup

# VM execution progress
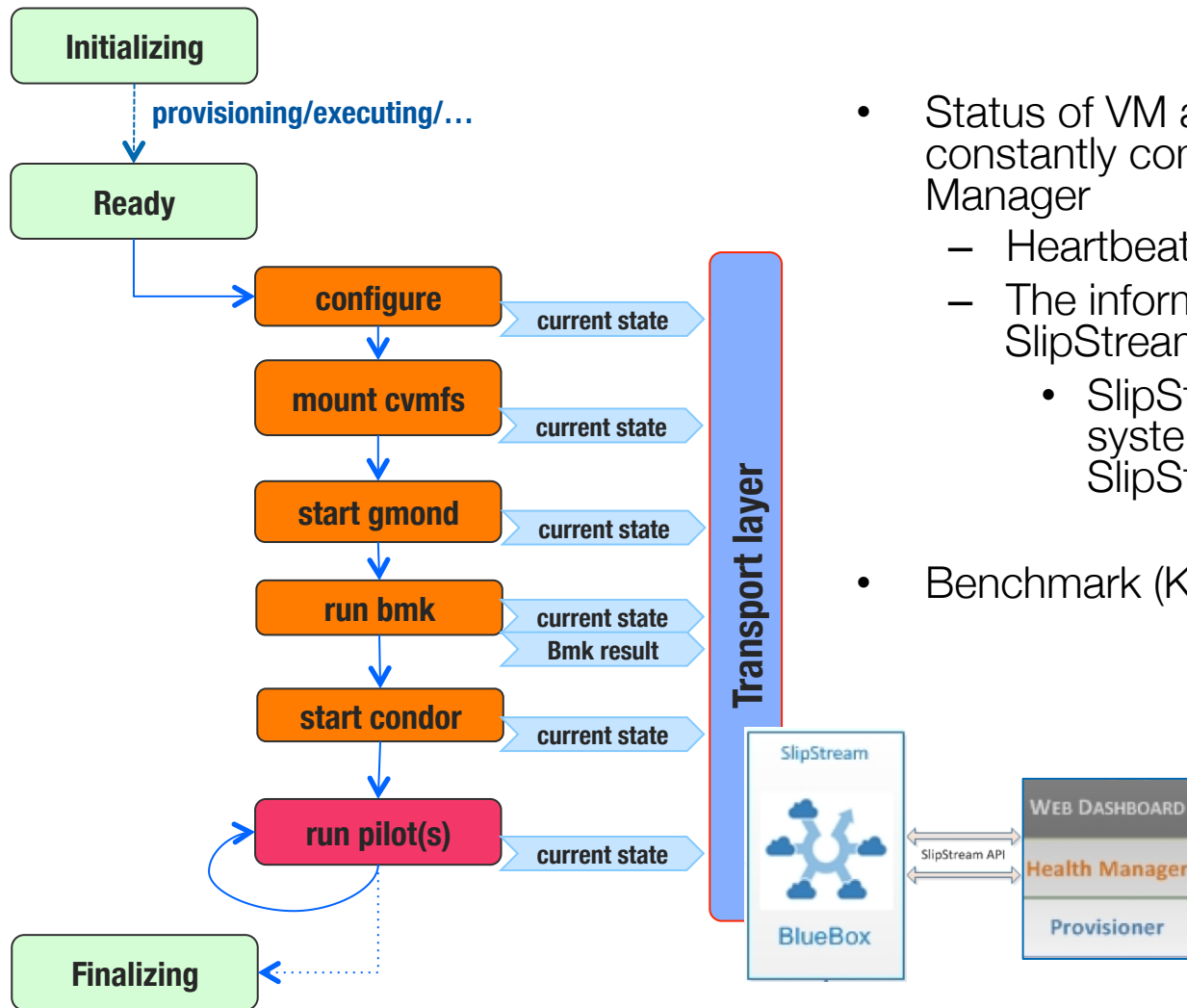


- Status of VM and running services is constantly communicated to the Resource Manager
  - Heartbeats and sensors
  - The information is retrieved from SlipStream dashboard
    - SlipStream includes a messaging system between the VMs and SlipStream server

- Benchmark (KV) runs before starting condor

# Results in a nutshell
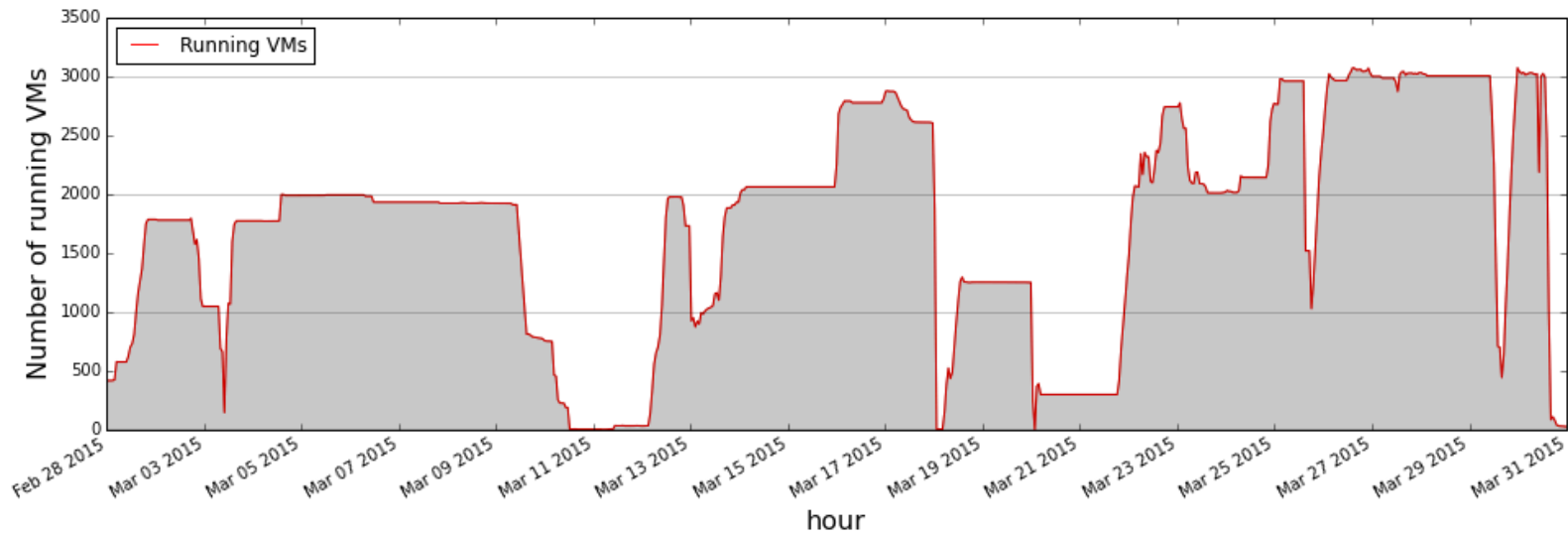


- Up to **3,000** concurrent running VMs
  - 4 (+1) weeks of production
  - ~1.2 million CPU hours of processing

- ATLAS GEANT4 Simulation of $t\bar{t}$ events
  - ~11.5 million events processed ⇔ ~80,000 jobs
  - ~93% CPU/Wall time ratio
    - ~9 hours single job duration
  - ~97% job wall time used for successful runs
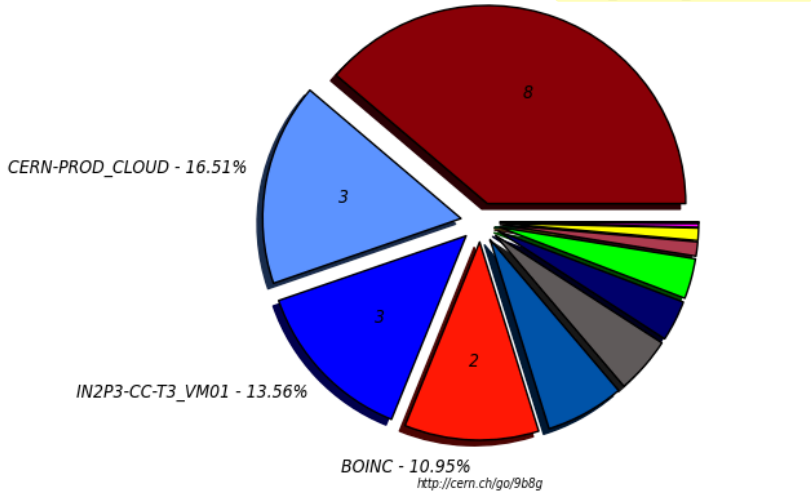    - Lost heartbeat is the main source of failures (~81%)
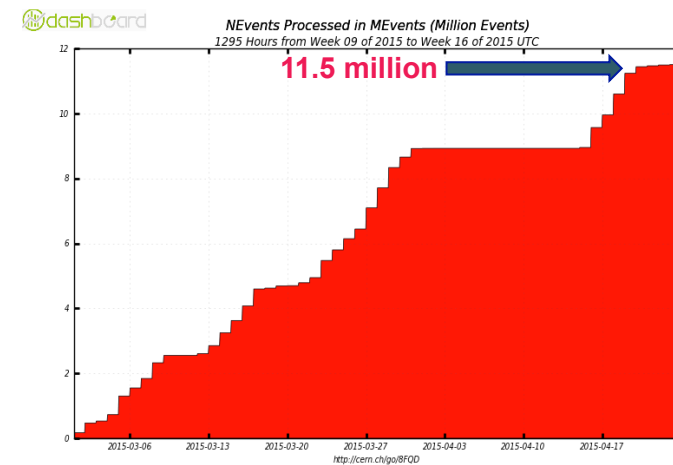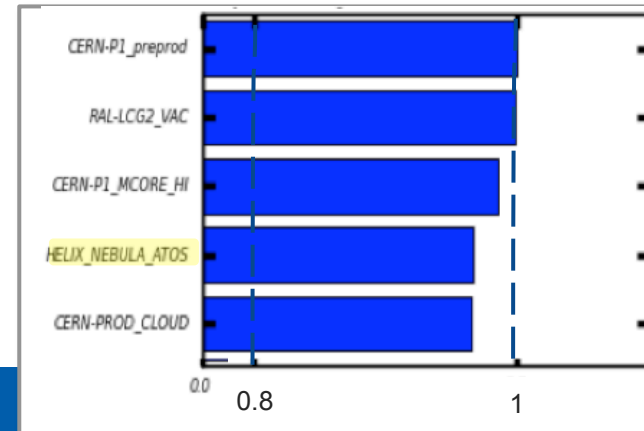
# Compared with other ATLAS cloud sites (March)



NEvents Processed in MEvents (Million Events) (Sum: 23.00)

HELIX_NEBULA_ATOS - 38.78%
CERN-PROD_CLOUD - 16.51%
IN2P3-CC-T3_VM01 - 13.56%
BOINC - 10.95%
http://cern.ch/go/9b8g

- HELIX_NEBULA_ATOS - 38.78% (9.00)
- IN2P3-CC-T3_VM01 - 13.56% (3.00)
- CERN-P1_MCORE_HI - 6.41% (1.00)
- IAAS - 3.32% (1.00)
- UKI-SOUTHGRID-OX-HEP_VAC - 1.15% (0.00)
- UKI-NORTHGRID-LANCS-HEP_CLOUD - 0.31% (0.00)
- GRIDPP_CLOUD - 0.02% (0.00)
- CERN-P1_preprod - 0.00% (0.00)

- CERN-PROD_CLOUD - 16.51% (4.00)
- BOINC - 10.95% (3.00)
- IAAS_MCORE - 4.64% (1.00)
- UKI-NORTHGRID-MAN-HEP_VAC - 3.28% (1.00)
- RAL-LCG2_VAC - 1.01% (0.00)
- CERN-P1_MCORE - 0.05% (0.00)
- HELIX_NEBULA_EGI - 0.01% (0.00)

- Significant contribution compared with other ATLAS cloud sites running simulation
  - **Largest** # of processed events
  - **Longest** wall time consumption
  - **High** wall time efficiency

*(\*) CERN-PROD_CLOUD: 90% of processed events belongs to fast workloads (~24 s/evt)*



Wall time consumption in seconds [1.e9]

completed  successful  failed



CERN-P1_preprod
RAL-LCG2_VAC
CERN-P1_MCORE_HI
HELIX_NEBULA_ATOS
CERN-PROD_CLOUD

# Comparison with all ATLAS single core simulations in March



**NEvents Processed in MEvents (Million Events) (Sum: 214.00)**

Rest - 36.71%

78

http://cern.ch/go/MI7V
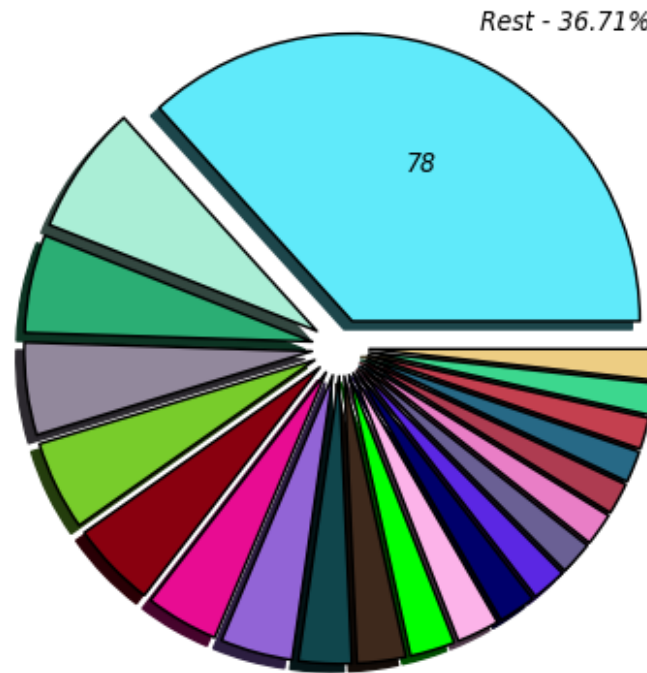
- ☐ Rest - 36.71% (79.00)
- ☐ RAL-LCG2_SL6 - 5.53% (12.00)
- ☐ UKI-NORTHGRID-LANCS-HEP_SL6 - 5.04% (11.00)
- ☐ UKI-SCOTGRID-GLASGOW_SL6 - 4.11% (9.00)
- ☐ CONNECT - 2.96% (6.00)
- ☐ CERN-PROD - 2.53% (5.00)
- ☐ BU_ATLAS_Tier2_SL6 - 2.11% (5.00)
- ☐ UKI-NORTHGRID-MAN-HEP_SL6 - 1.87% (4.00)
- ☐ CERN-PROD_CLOUD - 1.78% (4.00)
- ☐ UKI-LT2-QMUL_SL6 - 1.77% (4.00)

- ☐ TRIUMF - 7.27% (16.00)
- ☐ IN2P3-CC - 5.20% (11.00)
- ☐ BNL_PROD - 4.82% (10.00)
- ☐ HELIX_NEBULA_ATOS - 4.06% (9.00)
- ☐ UKI-SOUTHGRID-OX-HEP_SL6 - 2.74% (6.00)
- ☐ UKI-SOUTHGRID-RALPP_SL6 - 2.40% (5.00)
- ☐ FZK-LCG2 - 1.97% (4.00)
- ☐ INFN-T1 - 1.85% (4.00)
- ☐ UKI-LT2-Brunel_SL6 - 1.78% (4.00)
- *plus 2 more*

Helix Nebula has been the 7th ATLAS resource in terms of sim events processed in March by ATLAS single cores

# The monthly activity: Ganglia source
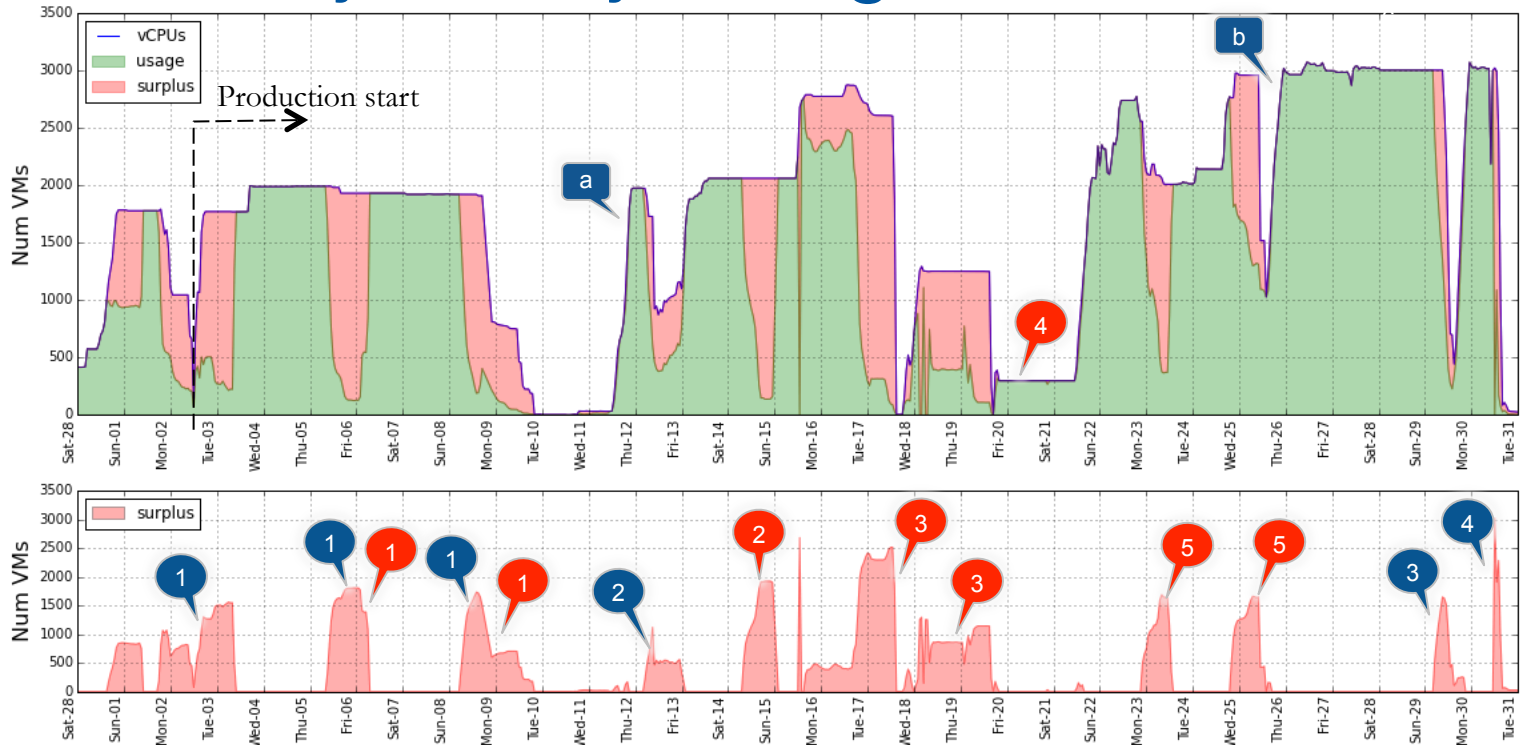


**Reasons**

**CERN**

1. Task completed (no more jobs)
2. CERN network issues
3. Agent auth. cache not renewed
4. Task abruptly terminated

a. Improvement: auto-scaling (up/down) based on load
b. Improvement: Orchestrator-less single-VM runs

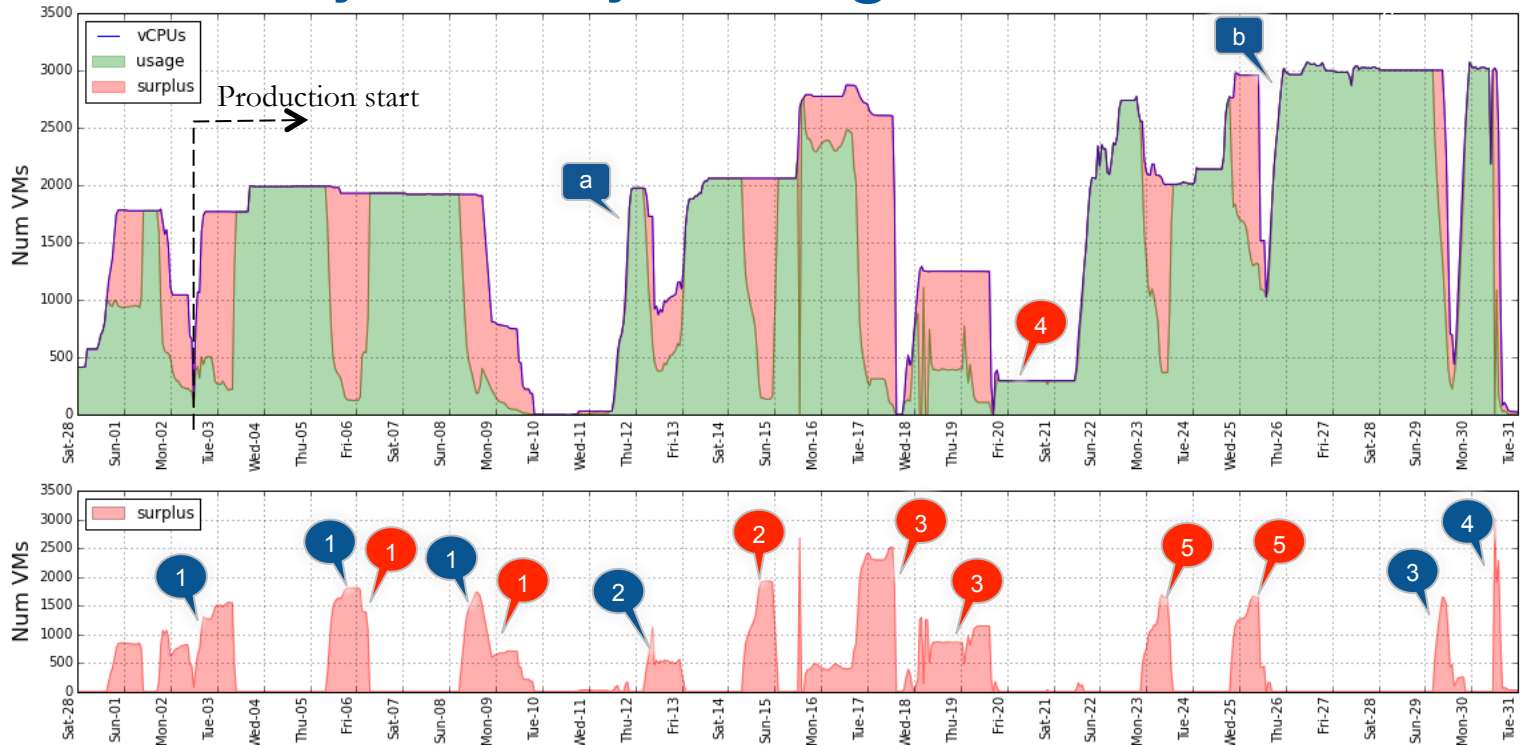**Surplus**: amount of running VMs not effectively used for production

**IaaS**

1. VMs stuck in provisioning
2. Missing cloud layer report
3. Read-only file system
4. Stuck orchestrators
5. Stuck deployments

# The monthly activity: Ganglia source



CERN

1 Task completed (no more jobs)
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a Improvement: auto-scaling (up/down) based on load
b Improvement: Orchestrator-less single-VM runs

Resource usage:
• Effective: 77%
   – Surplus causes 10% CERN, 13% IaaS
• After improvement "b":
   – Effective: 93%

Reasons

IaaS

VMs stuck in provisioning 1
Missing cloud layer report 2
Read-only file system 3
Stuck orchestrators 4
Stuck deployments 5

# Consumer-side accounting

- Requirements
  - Validate the invoices received about the used resources
  - Monitor the effective usage of resources and identify inefficiencies

- CERN Ganglia monitoring as been the **reference** for used resources
  - IaaS accounting in agreement with CERN Ganglia report
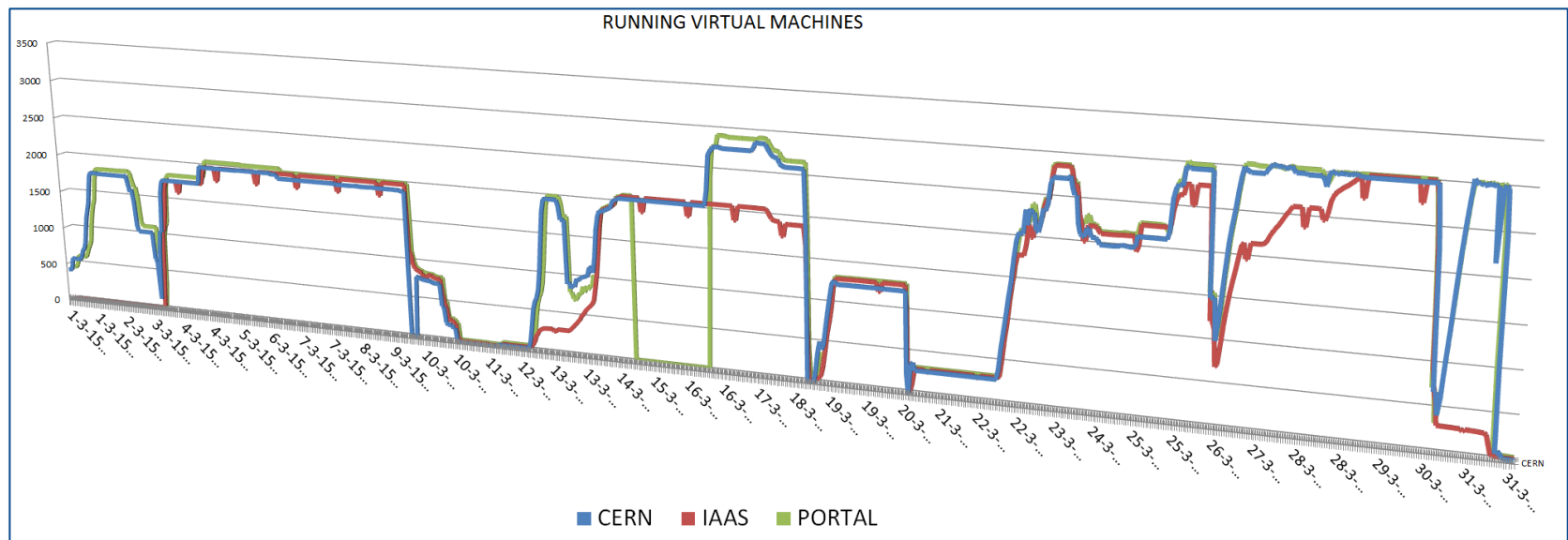
# Benchmarking

- Each created VM has been benchmarked using ATLAS KitValidation
  - ~30,000 VM benchmark performed
  - 100 Single Muon events simulated (~2 min to run)
- Results
  - CPU performance uniform within 15% spread
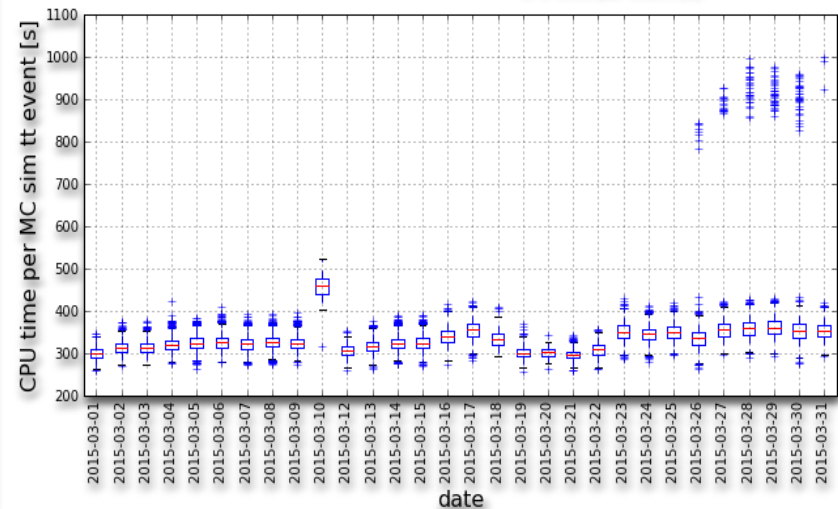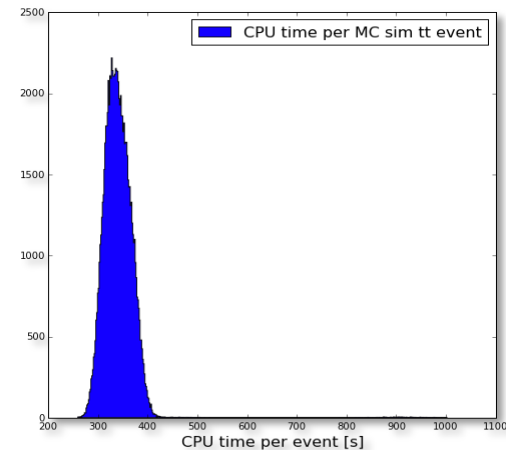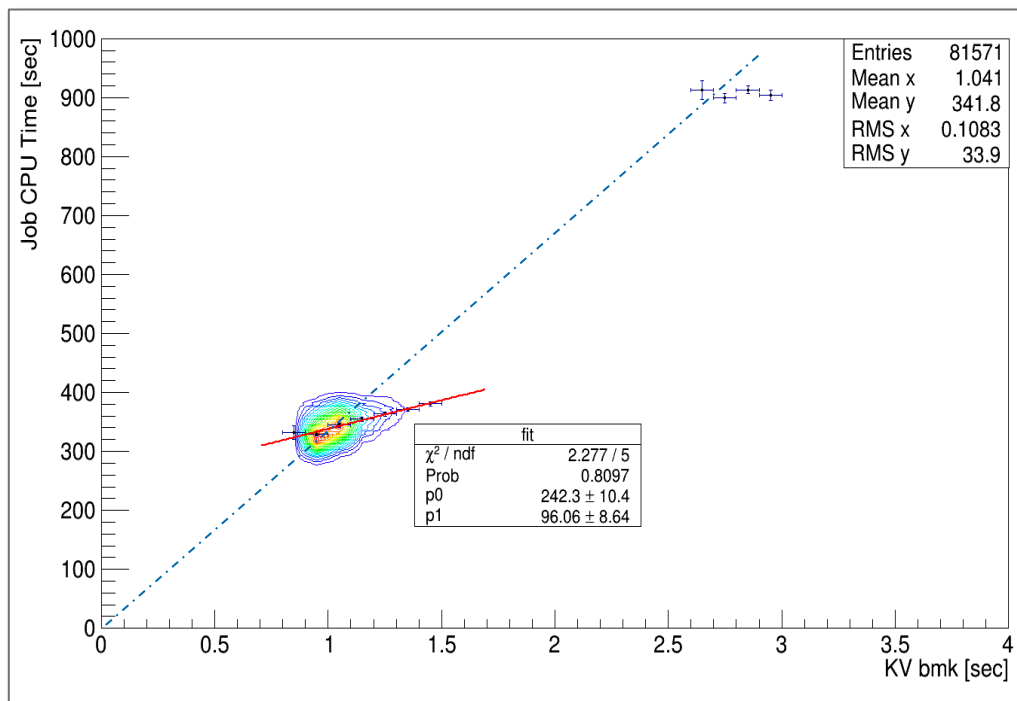  - Benchmark profile consistent over time
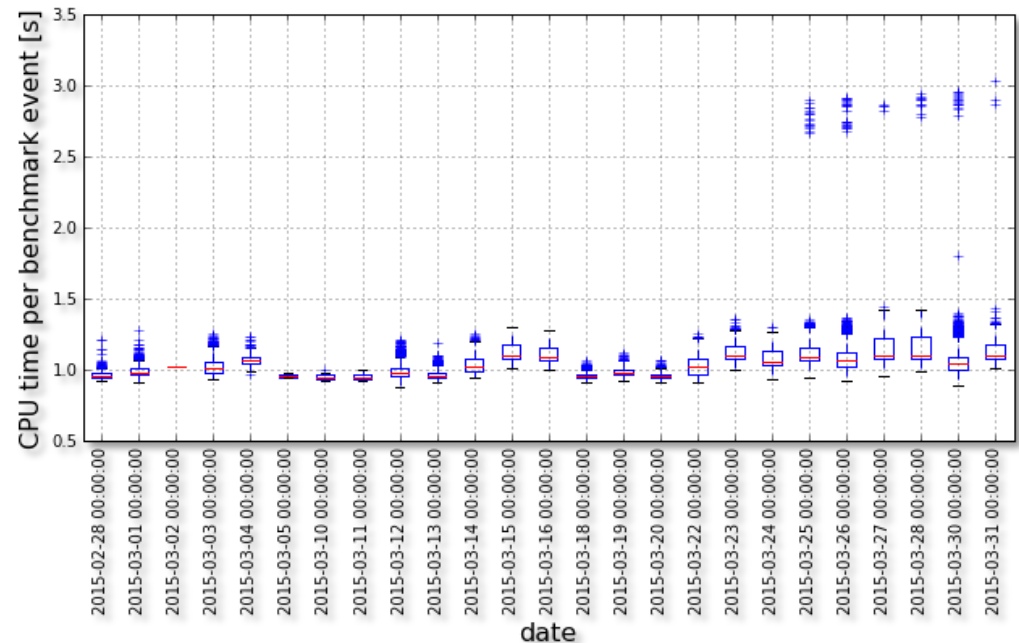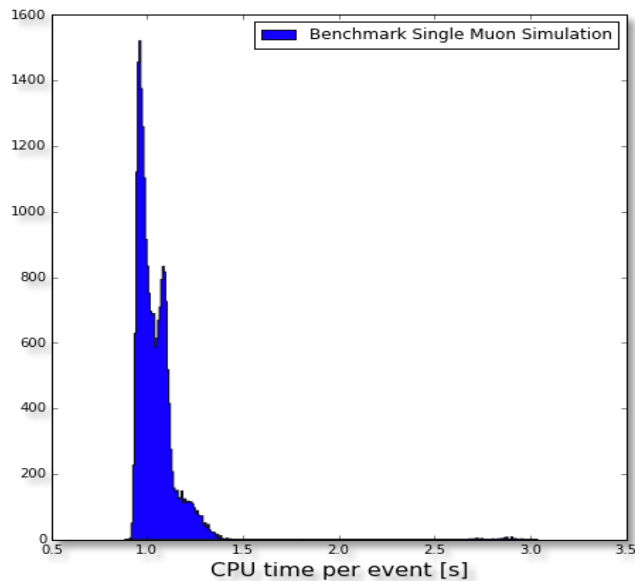
# Benchmarks vs Job performance

- **Consistent** job CPU performance and benchmark
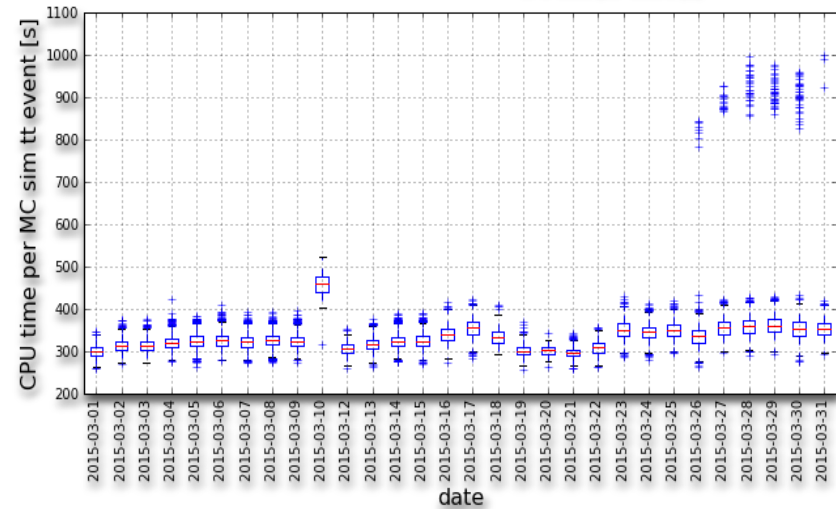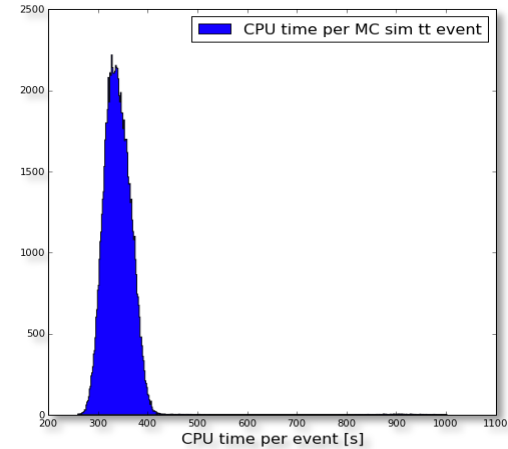
# Benchmarks vs Job performance

- **Consistent** job CPU performance and benchmark
  - Correlated behavior
- Outliers detection
  - KV bmk (2') is a *prompt and effective solution* to identify VMs with poor performance
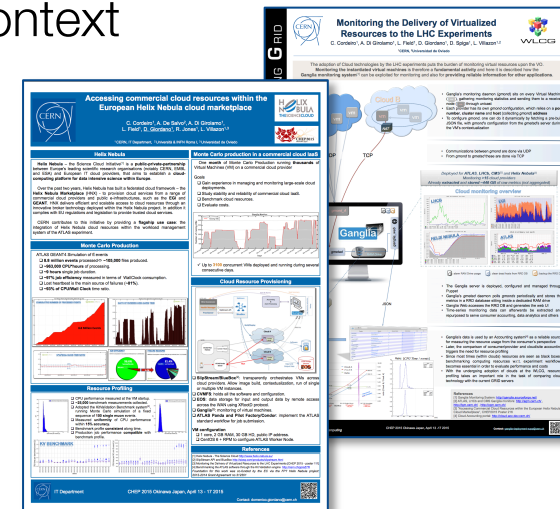
# Activity organization

- CERN IT-SDC team: Cris, Luis, Alessandro, Domenico
  - Crucial support from ADC people: in particular P. Love, J. E. Garcia



- Activity tracking: CERN Jira project
  - Over **100** tickets
    - Issue tracking and consolidation work, daily monitoring, time tracking
    - ~30 FTE days (**240 hours**) over 74 days of overall activity
      - 3 areas: tool consolidation (~8 FTE days), pre-prod (~13 FTE days), prod (~9 FTE days)

- Regular **CERN-SixSQ-Atos meetings** (15 of ~1h each)
  - Comprehensive **notes** of Issues and Actions
  - Established ticketing system to notify issues with Atos
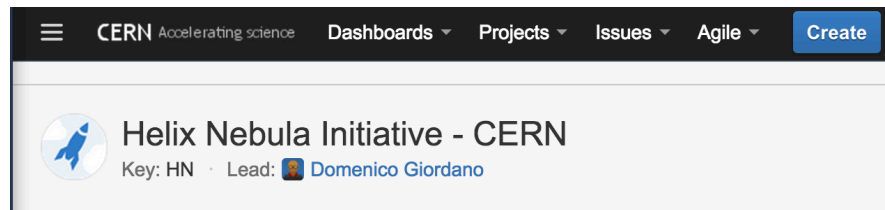
# Lessons learned

- **Successful** ATLAS production with ~11.5 million events processed

- **Beneficial** experience
  - Managing VMs (and facing issues) in a "cloudy" commercial IaaS
  - Monitoring, accounting and benchmarking cloud resources

- Client-side accounting is mandatory in a commercial context

- Benchmarking of each single VM is possible
  - Adopted fast benchmark running at VM startup
  - Transparently used in other commercial cloud IaaS

- Results reported at CHEP'15
  - Two contributions: Helix Nebula, Ganglia

- Next CERN procurement initiatives [See R. Jones talk at previous GDB]
  - Continue evaluation & integration of commercial cloud IaaS

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Domenico Giordano     17