



Distributed Computing Grid Experiences in CMS Data Challenge



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CMS Data Challenge 2004



Planned to reach a complexity scale equal to about 25% of that foreseen for LHC initial running

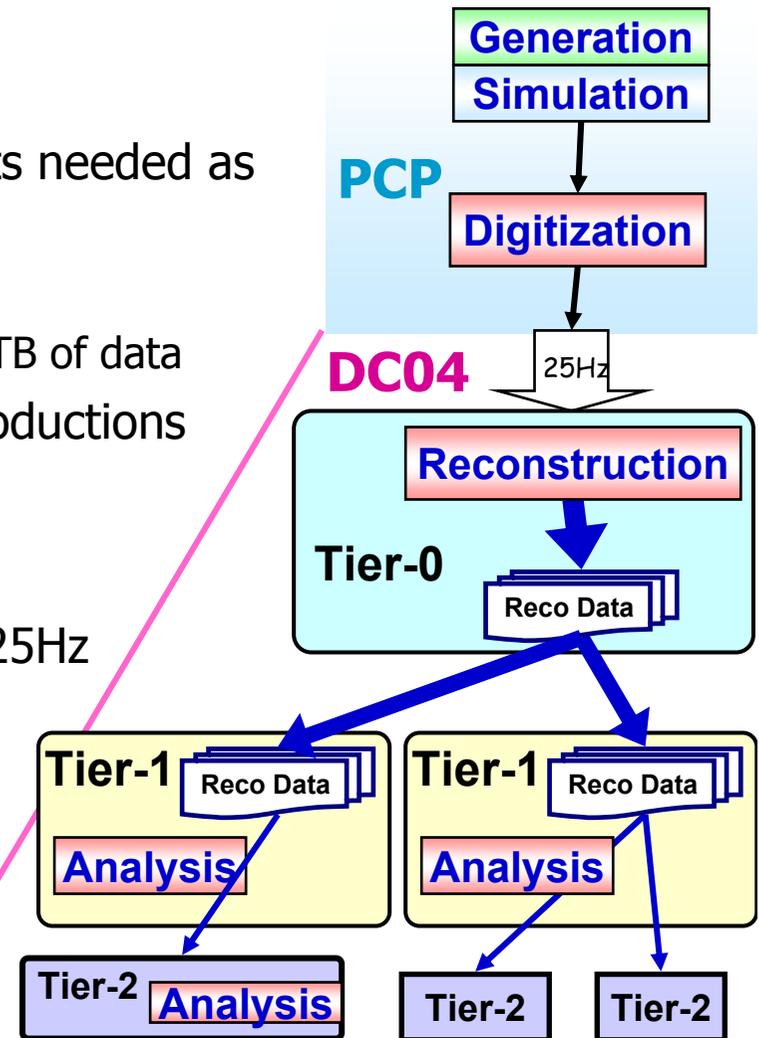
► Pre-Challenge Production in 2003/04 (PCP)

- ✳ Simulation and digitization of ~70 Million events needed as input for the Data Challenge
 - ◆ started in July 2003, Digitization still running
 - ◆ 750K jobs, 3500 KSI2000 months, 700 Kfiles, 80 TB of data
- ✳ Classic and Grid (CMS/LCG-0, LCG-1, Grid3) productions

► Data Challenge (DC04)

- ✳ Reconstruction of data for sustained period at 25Hz
- ✳ Data distribution to Tier-1, Tier-2 sites
- ✳ Data analysis at remote sites
- ✳ Demonstrate the feasibility of the full chain

→Talk ID 498 T5 , D. Bonacorsi "Role of Tier-0, Tier-1 and Tier-2 Regional Centers during CMS DC04"

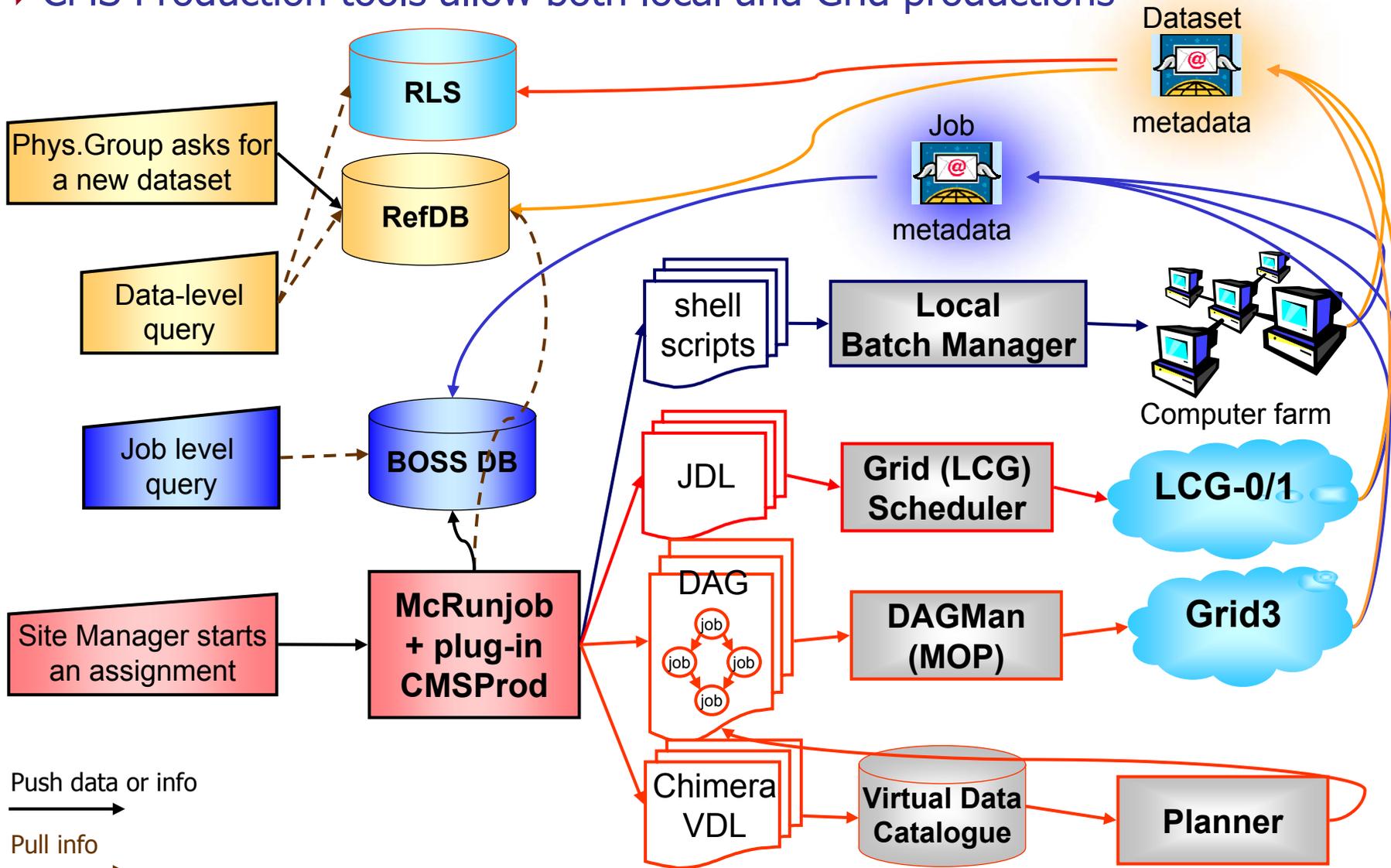




Pre-Challenge Production setup



► CMS Production tools allow both local and Grid productions



Push data or info
 →
 Pull info
 - - - - -



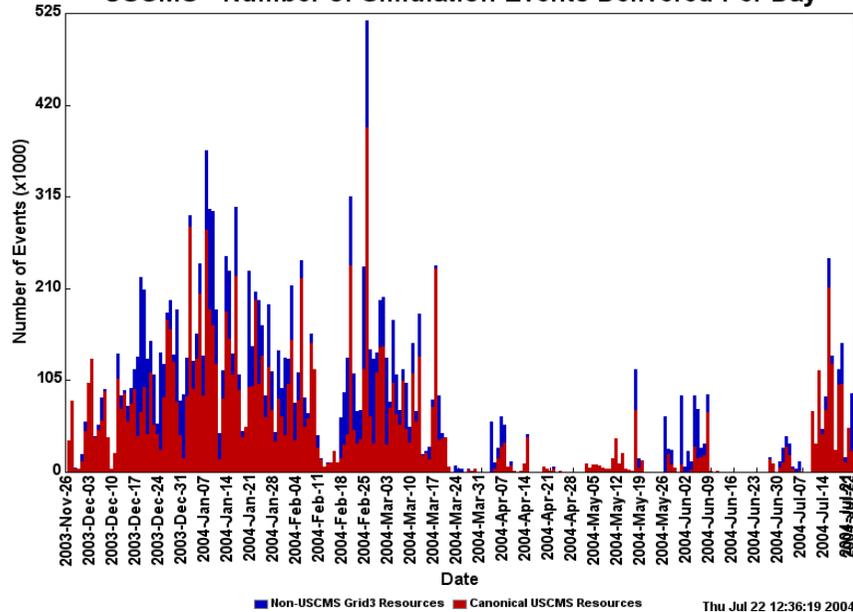
Production on Grid: Grid3



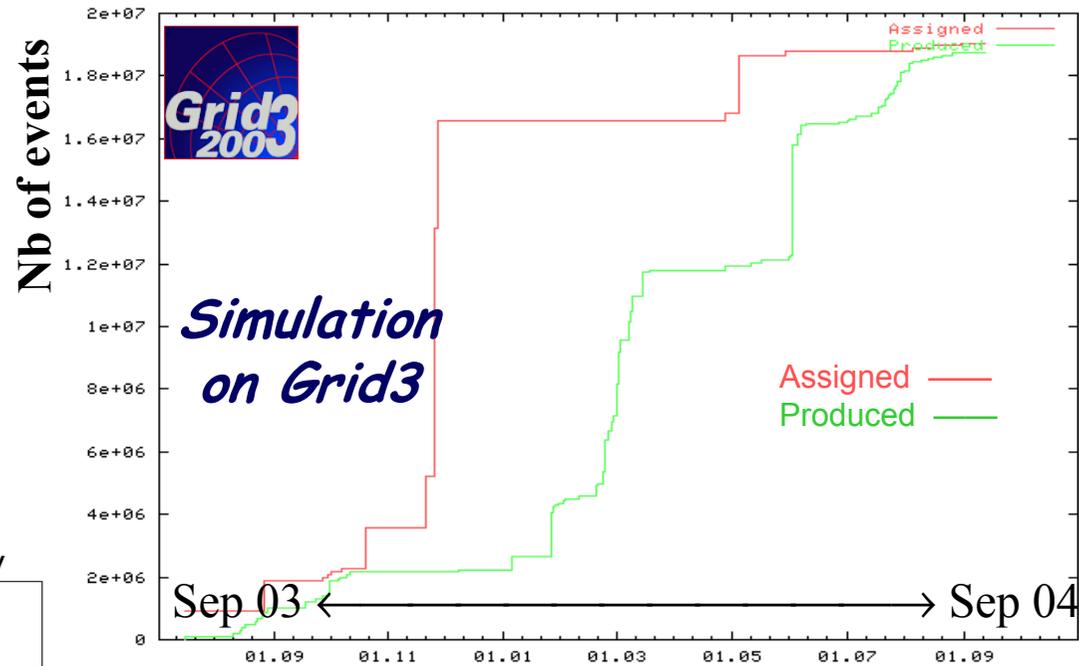
Resources:

- ▶ US CMS Canonical resources (Caltech,UCSD,Florida,FNAL)
 - ✱ 500-600 CPUs
- ▶ Grid3 shared resources (~17 sites)
 - ✱ over 2000 CPUs (shared)
 - ✱ realistic usage (few hundred to 1000)

USCMS - Number of Simulation Events Delivered Per Day



Thu Jul 22 12:36:19 2004 GMT



USMOP Regional Center Statistics:

- ▶ 7.7 Mevts CMKIN
 - ✱ 30000 jobs ~ 0.7 KSI2000 months
- ▶ 19 Mevts CMSIM+OSCAR
 - ✱ 19000 jobs ~ 1000 KSI2K months
- ▶ 13 TB data



Grid3: results and observations



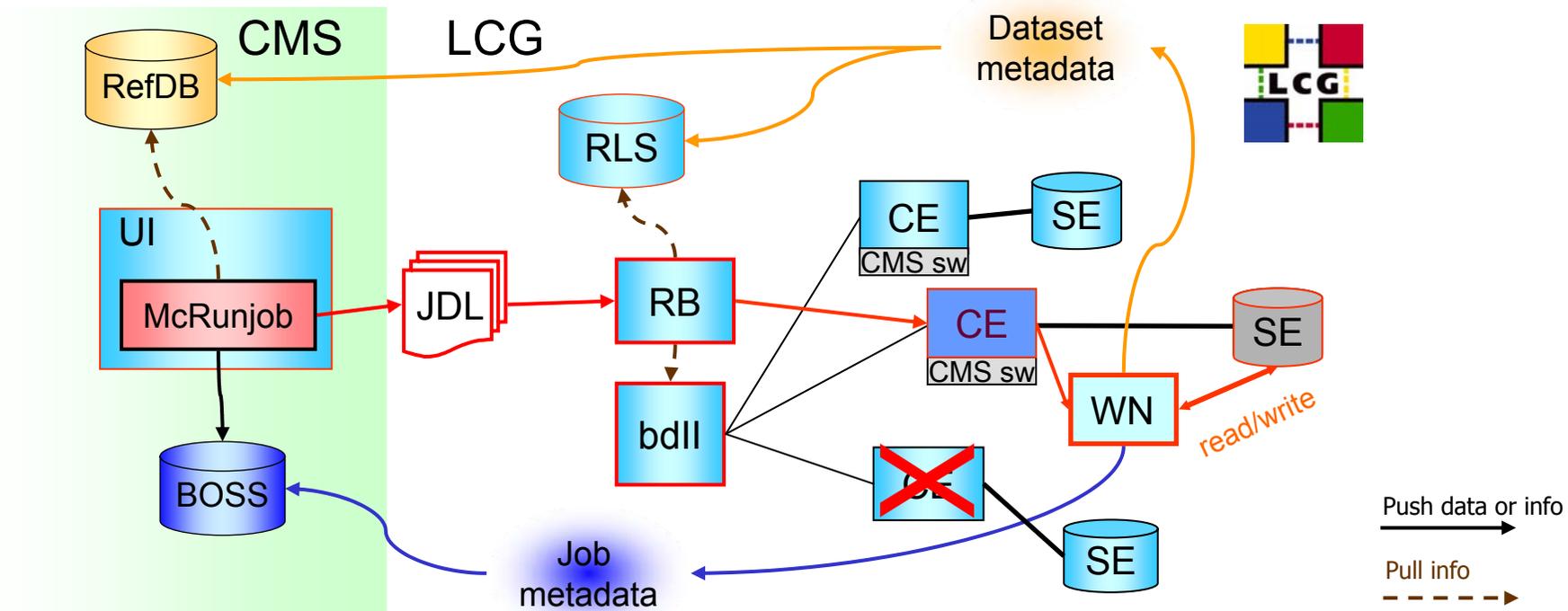
- ▶ Massive CMS Official Production on Grid3
 - * ~ 19 Millions of events (19K very long jobs), 13TB data
 - * Simultaneous usage of CPU resources peaked at 1200 CPUs, controlled by a single FTE
- ▶ Overall Job Efficiency ~ 70%
- ▶ Reasons of job failures
 - * CMS application bugs ~ few %
 - * No significant failure rate from Grid middleware per se
 - ◆ can generate high loads
 - ◆ infrastructure relies on shared filesystem
 - * Most failures due to "normal" system issues
 - ◆ hardware failure
 - ◆ NIS, NFS problems
 - ◆ disks fill up
 - ◆ Reboots
 - * Service level monitoring need to be improved
 - ◆ a service failure may cause all the jobs submitted to a site to fail
- ▶ The use of Grid-based jobs resulted in reducing the overall support effort required to submit and monitor jobs by a factor of two



CMS production interfaced to LCG



- ▶ Production is managed from User Interface
- ▶ CMS software installed on CE as RPM's



- ▶ Computing resources are matched by the Resource Broker to the job requirements (installed CMS software, MaxCPUtime, etc)
- ▶ Output data stored into close SE and registered in RLS



Production on grid: CMS-LCG



Resources:

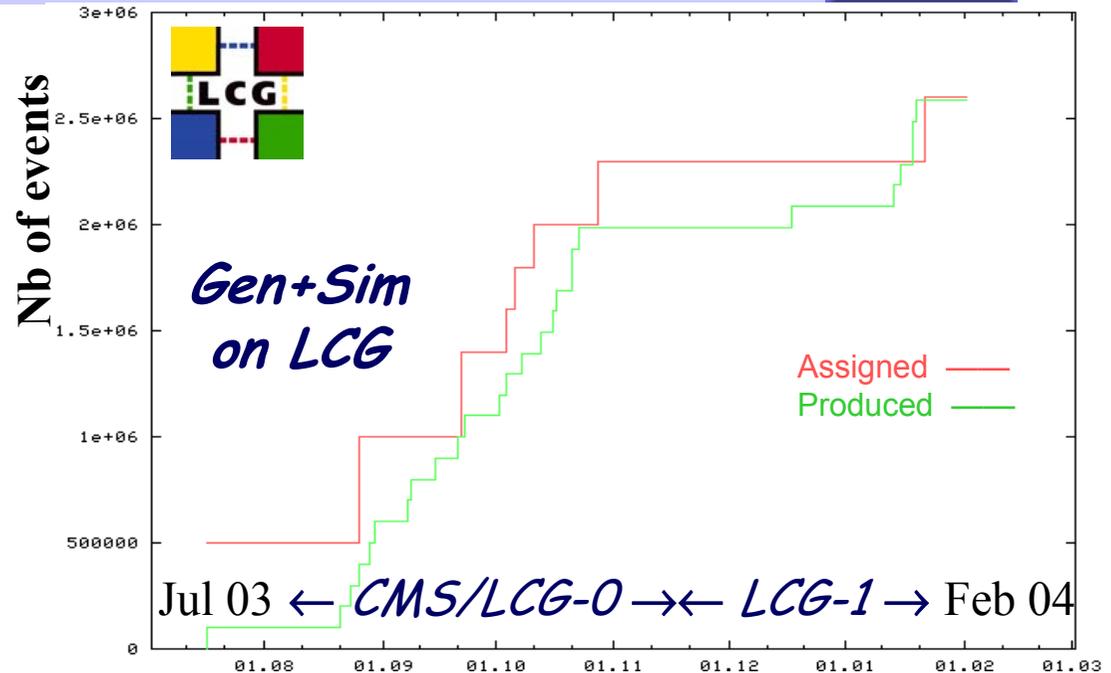
About 170 CPU's and 4TB

▶ CMS/LCG-0

- * CMS-wide testbed (~10 sites) based on the LCG pilot distribution (LCG-0) including RLS, VOMS, GLUE schema, GridICE...

▶ LCG-1

- * sites of "south testbed" (Italy-Spain)/Gridit



CMS-LCG Regional Center Statistics:

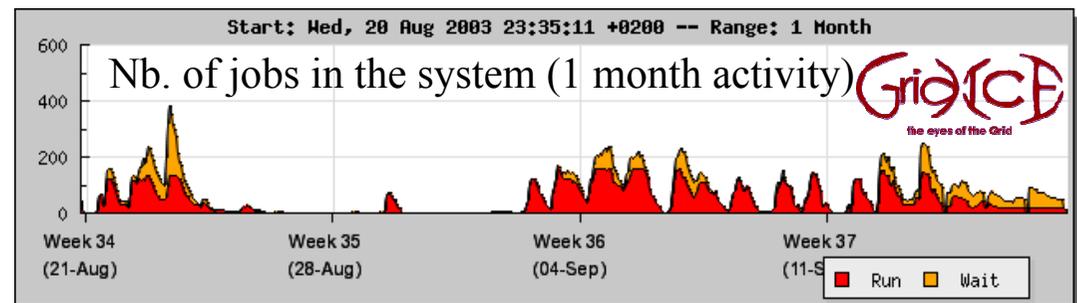
▶ 0.5 Mevts "heavy" CMKIN

- * 2000 jobs ~ 10 KSI2K months

▶ 2.1 Mevts CMSIM+OSCAR

- * 8500 jobs ~ 90 KSI2K months

▶ ~ 2 TB data





LCG: results and observations



- ▶ CMS Official Production on early deployed LCG implementations
 - ✱ ~ 2.6 Millions of events (~ 10K long jobs), 2TB data
- ▶ Overall Job Efficiency ranging from 70% to 90%
- ▶ The failure rate varied depending on the incidence of some problems:
 - ◆ RLS unavailability few times, in those periods the job failure rates could increase up to 25-30% → single point of failure
 - ◆ Instability due to site mis-configuration, network problems, local scheduler problem, hardware failure with overall inefficiency about 5-10%
 - ◆ Few % due to service failures
- ▶ Success Rate on LCG-1 was lower wrt CMS/LCG-0 (efficiency ~ 60%)
 - ◆ less control on sites, less support for services and sites (also due to Christmas)
 - ◆ Major difficulties identified in the distributed sites consistent configuration
- ▶ Good efficiencies and stable conditions of the system in comparison with what obtained in previous challenges
 - ✱ showing the maturity of the middleware and of the services, provided that a continuous and rapid maintenance is guaranteed by the middleware providers and by the involved site administrators



LCG-2 in CMS Data Challenge 04



Aspects of DC04 involving LCG-2 components

- * register all data and metadata to a world-readable catalogue
 - ◆ RLS
 - * transfer the reconstructed data from Tier-0 to Tier-1 centers
 - ◆ Data transfer between LCG-2 Storage Elements
 - * analyze the reconstructed data at the Tier-1's as data arrive
 - ◆ Real-Time Analysis with Resource Broker on LCG-2 sites
 - * publicize to the community the data produced at Tier-1's
 - ◆ straightforward using the usual Replica Manager tools
 - * end-user analysis at the Tier-2's (not really a DC04 milestone)
 - ◆ first attempts
 - * monitor and archive resource and process information
 - ◆ GridICE
- ▶ Not a CPU challenge, but a full chain demonstration!
- ▶ Full chain (but the Tier-0 reconstruction) done in LCG-2



Description of CMS/LCG-2 system



- ▶ RLS at CERN with Oracle backend
- ▶ Dedicated information index (bdII) at CERN (by LCG)
 - ✱ CMS adds its own resources and removes problematic sites
- ▶ Dedicated Resource Broker at CERN (by LCG)
 - ✱ Other RB's available at CNAF and PIC, in future use them in cascade
- ▶ Official LCG-2 Virtual Organization tools and services
- ▶ Dedicated GridICE monitoring server at CNAF
- ▶ Storage Elements
 - ✱ Classic disk SE at CERN → Export Buffer
 - ✱ Castor SE at CNAF and PIC → import buffer from CERN and interface to MSS
 - ✱ Classic disk SE at CNAF, PIC, Legnaro, Ciemat → serve data for analysis
- ▶ Computing Elements at CNAF, PIC, Legnaro, Ciemat
 - ✱ CMS Software installed on CE by the CMS Software Manager via a grid job
 - ◆ RPM distribution based on CMSI
- ▶ User Interfaces at CNAF, PIC, LNL



RLS usage



- ▶ CMS framework uses POOL
- ▶ RLS used as a global POOL catalogue, with full file meta data
 - ✱ Global file catalogue (LRC component of RLS: GUID ↔ PFNs)
 - ◆ Registration of files location by reconstruction jobs and by all transfer tools
 - ◆ Query by the Resource Broker to submit analysis jobs close to the data
 - ✱ Global metadata catalogue (RMC component of RLS: GUID ↔ metadata)
 - ◆ Meta data schema handled and pushed into RLS catalogue by POOL
 - ◆ Query (by users or agents) to find logical collection of files
 - ◆ CMS does not use a separate file catalogue for meta data
- ▶ Total Number of files registered in the RLS during DC04:
 - ✱ ~ 570K LFNs each with ~ 5-10 PFN's
 - ✱ 9 metadata attributes per file (up to ~1 KB metadata per file)

→Talk ID 383 T4 , M. Girone "Experience with POOL from the first three Data Challenges using the LCG"



RLS issues



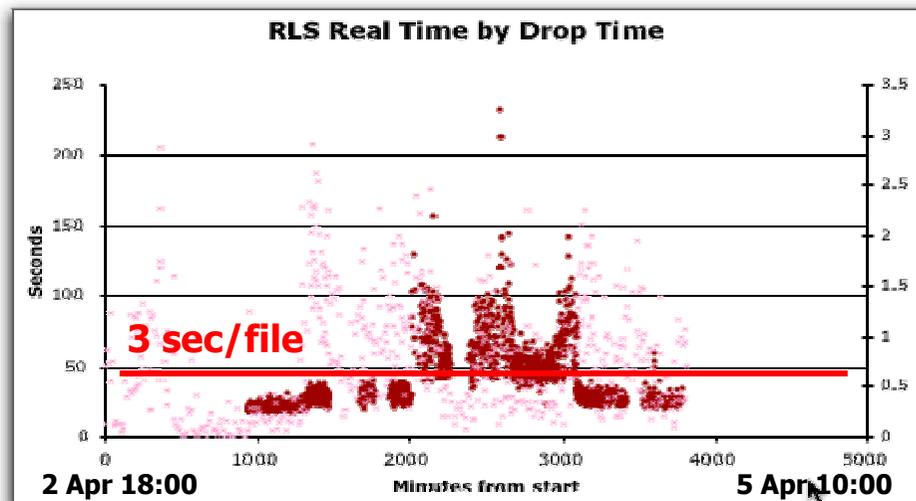
▶ Inserting information into RLS:

- ✱ insert PFN (file catalogue) was fast enough if using the appropriate tools, produced in-course
 - LRC C++ API programs (~0.1-0.2sec/file), POOL CLI with GUID (secs/file)
- ✱ insert files with their attributes (file and metadata catalogue) was slow
 - We more or less survived, higher data rates would be troublesome

▶ Querying information from RLS

- ✱ Looking up file information by GUID seems sufficiently fast
- ✱ Bulk queries by GUID took a long time (seconds per file)
- ✱ Queries on metadata are too slow (hours for a dataset collection)

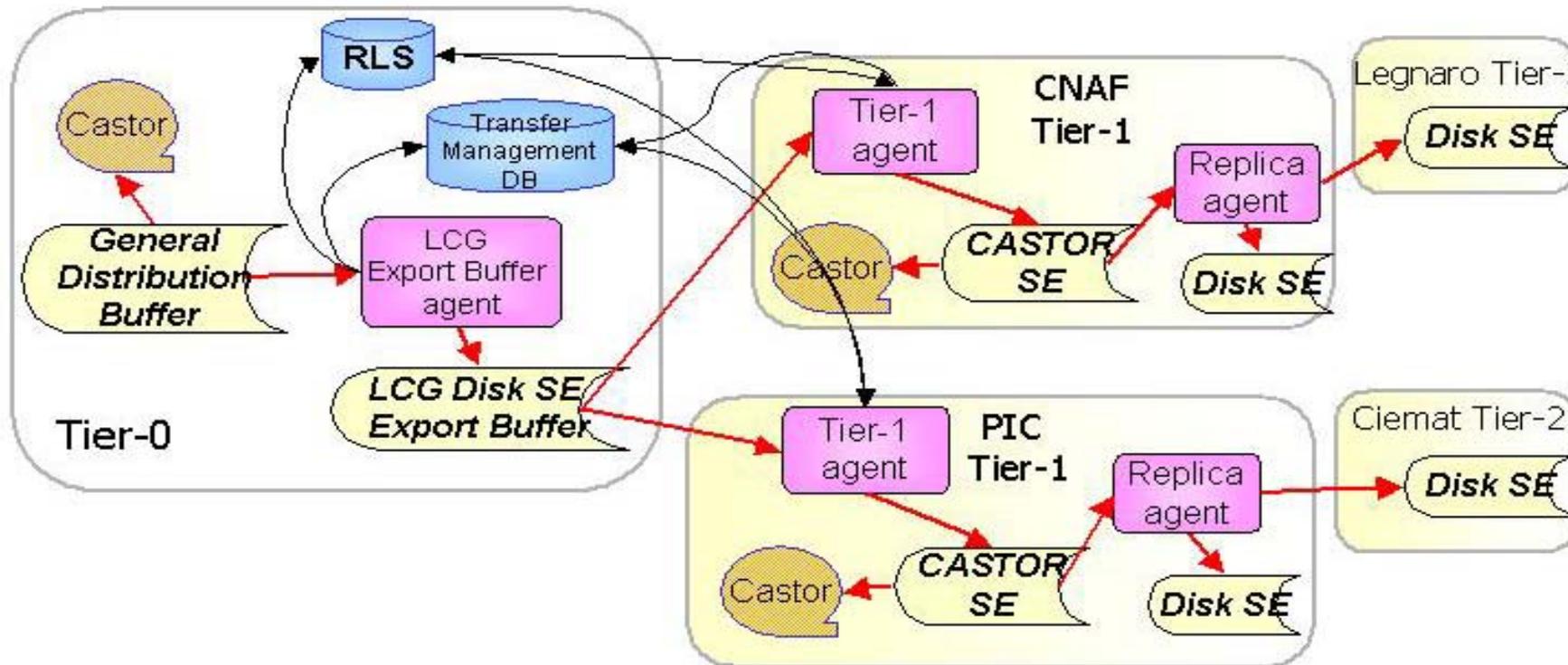
Time to register the output of a Tier-0 job (16 files)



Sometimes the load on RLS increases and requires intervention on the server (i.g. log partition full, switch of server node, un-optimized queries)

⇒ able to keep up in optimal condition, so and so otherwise

- ▶ Set of agents communicating through the Transfer Management DB (TMDB)
 - Talk ID 162 T4 , T. Barrass "Software agents in data and workflow management"



- * Data upload at Tier-0 in a disk SE Export Buffer and register in RLS
- * Data transfer from Tier-0 to CASTOR SEs at Tier-1
- * Data replication from Tier-1 to Tier-2 disk SEs



Data Transfer (II)



▶ Transfer tools:

- * Replica Manager CLI used for EB → CNAF and CNAF → Legnaro
 - ◆ Java-based CLI introduces non negligible overhead at start-up
- * globus-url-copy + LRC C++ API used for EB → PIC and PIC → Ciemat
 - ◆ Faster

▶ Performance has been good with both tools

- * able to keep up with the rate of data coming from the reconstruction at Tier-0
- * Total network throughput limited by small file size
- * Some transfer problem caused by performance of underlying MSS (Castor)



Real-time Data Analysis



→ Talk ID 132 T5 N. De Filippis "Tier-1 and Tier-2 Real-time Analysis experience in CMS DC04"

- ▶ Automatic procedures to submit analysis jobs as new data were made available on disk SE at Tier-1 and Tier-2

- ✱ Main difficulty is to identify complete file sets (i.e. runs)

- ▶ Job submission to LCG-2 Resource Broker

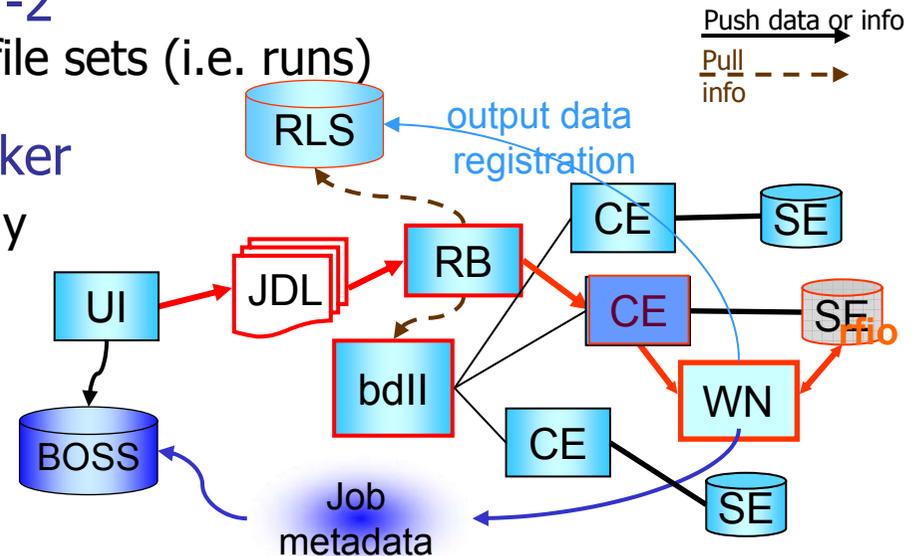
- ✱ running on LCG-2 sites (Spain and Italy Tier-1/2)

- ✱ Job sent close to the data

- ✱ File access via rfiio

- ✱ Output data registered in RLS

- ✱ Job monitoring with BOSS



- ▶ The LCG submission system could cope with the rate of data coming from CERN

- ✱ More than 17000 analysis jobs were submitted in about 2 weeks, with a grid efficiency of 90-95%

- ✱ During the last days of running an average delay of 20 minutes from data at Tier-0 to their analysis at Tier-1 was measured

- ▶ Real-time analysis sustained running was done only in LCG environment



Conclusions



- ▶ CMS distributed production based on grid middleware used within the official CMS production system
 - * Grid3: reliable and scalable system for massive production
 - * LCG: large scale productions proved
 - ◆ distributed sites consistent configuration and control is very important
- ▶ CMS Data Challenge
 - * LCG environment provides the functionalities for distributed computing
 - ◆ The catalogues are an issue!
 - ◆ Grid point-to-point file transfer tools
 - ◆ Infrastructure for data analysis
 - * LCG data distribution and data analysis chain successfully met the data challenge goals of large scale scheduled distribution to a set of Tier-1/2 and subsequent analysis