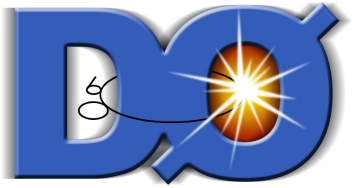
Distributed Monte Carlo Production For DZero



CHEP 2009 Prague
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Langston University

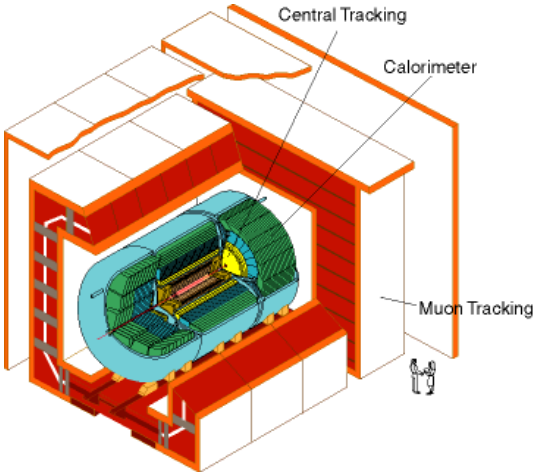
Outline

- Introduction
- DZero Experiment
- FNAL SAM
- SAMGrid
- Interoperability with OSG and LCG
- Production System
- Production Results
- Future Prospects
- Summary & Conclusion

Introduction

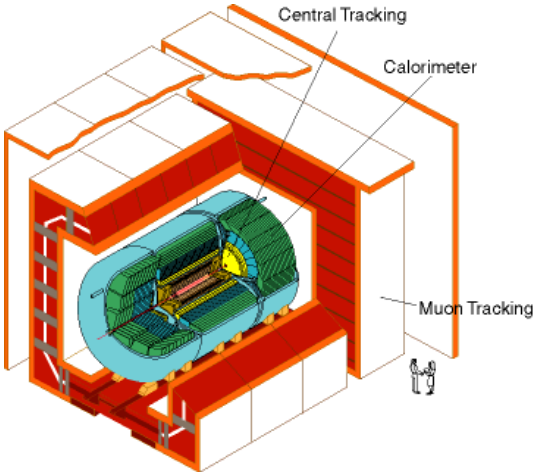
- Simulation data (MC) crucial to physics analysis
- Tevatron luminosity and hence raw data volume is at record levels
- Challenge for analysts and production
- Personnel & computing resources migrating to LHC experiments
- DZero strategy
  - Increase automation
  - Leverage resources and support

DZero Experiment



- Detector 30'x30'x50', 5000 tons
- ~1,000,000 data channels
- Inspects 1.7 million p anti-p collisions/sec
- Records ~100 events/sec
- Data flow 20MB/sec.
- 300,000 GB of data recorded/year
- 4.5 billion events recorded to date
- Took data 1992-1996, upgrade 1996-2001, running nearly continuously since

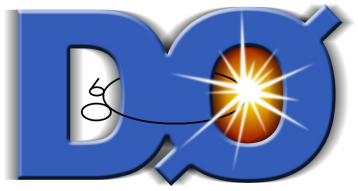
DZero Experiment



- Global enterprise
  - 550 scientists, 150 grad. students
  - 19 countries on 4 continents
  - 90 institutions (38 in U.S.)
- > 250 papers & > 250 Ph.D. theses to date
- Will run through 2010
- Expect to increase data set by 50-100%
- Challenging as resources migrate to LHC experiments

DZero Evolution

- Mature experiment, but nimble
  - history of adopting innovative technologies
    - distributed data handling - SAM
    - early adopter of the grid for production - SAMGrid
  - significant investment in these technologies
- Grid technology allows opportunistic usage
  - DZero can mix “traditional” dedicated and opportunistic resources
- Grid interoperability
  - Leverages resources and support, reduces personnel needs per CPU hour



Sequential data Access via Metadata

- Fermilab system first used by DZero
- SAM data handling system predates grid
- Set of servers working together to store and retrieve files and metadata
- Permanent storage and local disk caches
- Database tracks location, metadata of files, job processing history
- Delivers files to jobs (using GridFTP over WAN), provides job submission capabilities

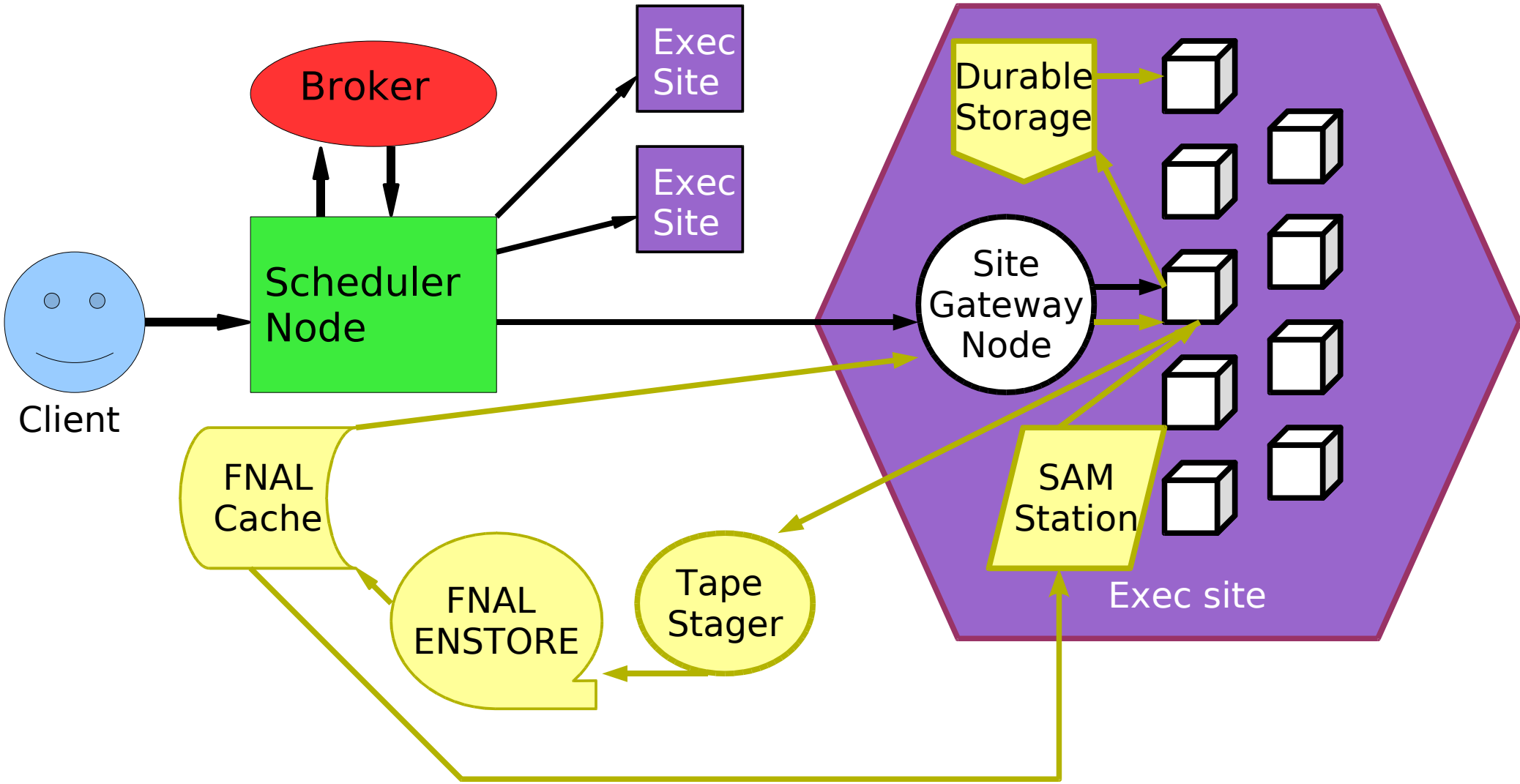
SAMGrid

- Fermilab developed grid first used by DZero for global MC production in 2004
- SAMGrid = SAM + Job and Information Management (JIM) components
- Provides the user with transparent remote job submission, data processing and status monitoring.
- VDT based (Globus + Condor)
- Logically consists of
  - Multiple execution sites
  - Resource selector
  - Multiple Job Submission (Scheduler) sites
  - Multiple Clients (User Interface) to Submission site.

SAMGrid Operation

- User submits job request to queuing node (based on Condor scheduler) via remote client (based on Condor client commands).
- Jobs are matched and submitted to execution sites (based on on Globus gatekeeper/jobmanager).
- At exec site job requests are split into multiple job instances (for MC 250 events/job)
- Job instances submitted to a local batch system or to another grid.
- Exec site triggers data delivery (binary, control, input data) and controls data traffic shaping.

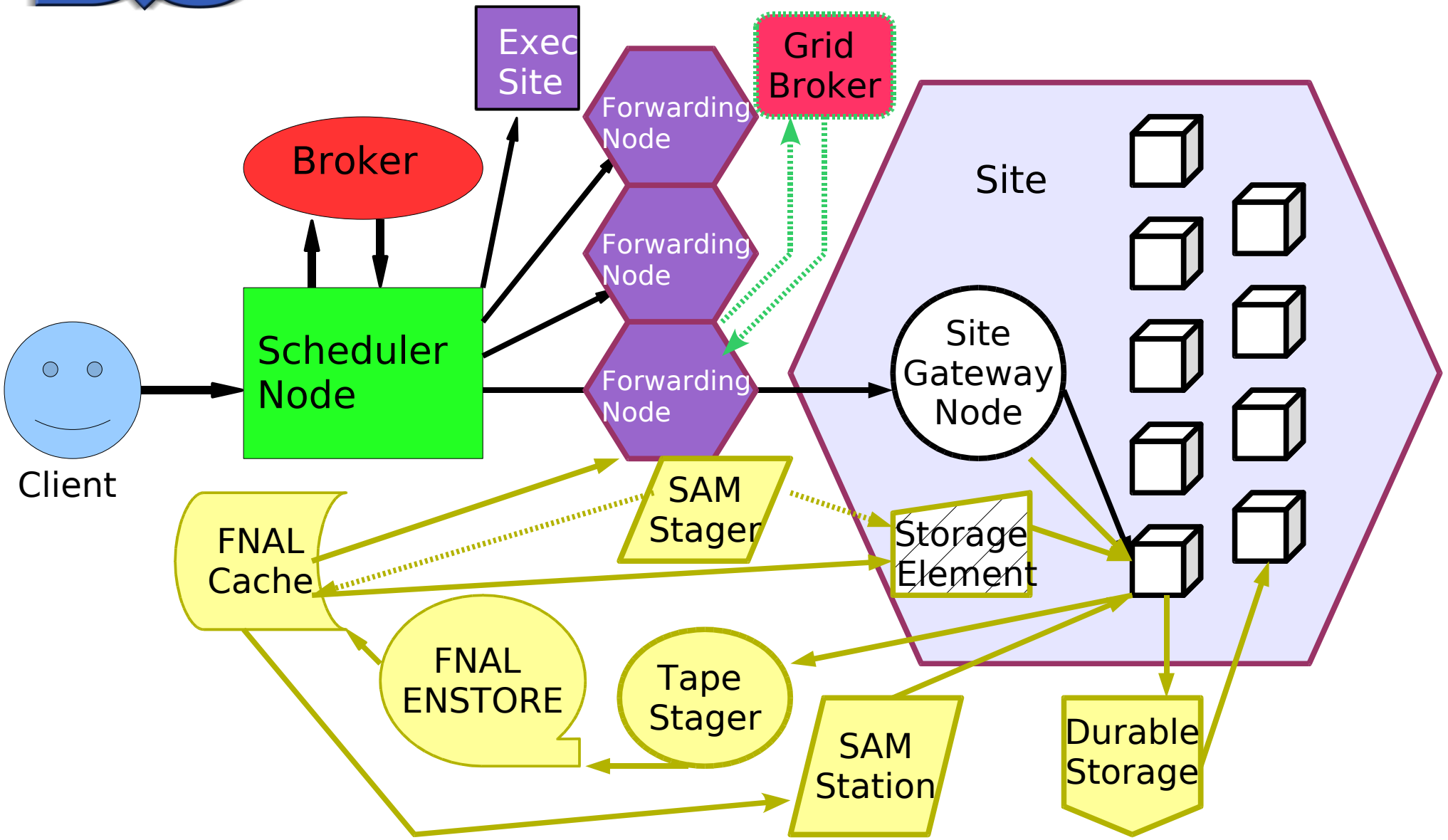
SAMGrid Components



SAMGrid Interoperability

- As Open Science Grid (OSG) and LHC Computing Grid (LCG) became operational it was desirable to leverage these resources for DZero
- FNAL and DZero developed and deployed SAMGrid interoperability with both LCG and OSG resources
- Execution site acts as a Forwarding node
  - packages SAMGrid jobs for OSG/LCG job submission via Condor-G/Glite

SAMGrid OSG/LCG



Consolidation, Automation, Exploitation

- ✦ SAMGrid sites require operational manpower and expert support
- ✦ People power and FNAL support migrating to LHC experiments
- ➡ Increase automation - Automc
- ➡ Reduce number of SAMGrid sites, increase use of OSG and LCG
  - comes with support ✔
  - provides opportunistic job slots ✔

Production System

- MC production gets work from the SAM Request System
  - Physics groups' MC requests are parametrized and prioritized

MC Request Summary

Group	Weight	Request Total	Processed Events	Weighted Events	Next Job
algo	1	2000000	1000000	1000000	0
bphysics	1	25400000	17900000	17900000	0
dzero	4	737789248	554765470	138691367	0
higgs	1	218478000	190253000	190253000	94799
jes	4	35400001	27000000	6750000	0
np	1	58849999	41385001	41385001	0
qcd	1	6700000	6600000	6600000	0
test	1	2198001	1641000	1641000	0
top	1	221785000	162160000	162160000	94834
wz	1	11580000	10415000	10415000	0

The Next Request to be processed is Request ID = 94834

Updated Sat Nov 29 11:00:24 CST 2008

MC Requests 1

Updated Sat Nov 29 11:00:24 CST 2008

Request ID	Status	Group	User	Priority	# Events	Description	Cardfile Vers. Dir. Prod. Decay
95054	approved	top	mackin	5	100000	p20 pythia t+t->incl m_t=185 gev with non-standard br	pythia --- v01-01-37 --- top --- t+t --- incl_BR.n
95053	approved	top	mackin	5	200000	p20 pythia t+t->incl m_t=185 gev with non-standard br	pythia --- v01-01-37 --- top --- t+t --- incl_BR.n
95052	approved	top	mackin	5	200000	p20 pythia t+t->incl m_t=185 gev with non-standard br	pythia --- v01-01-37 --- top --- t+t --- incl_BR.n
95051	approved	top	mackin	5	100000	p20 pythia t+t->incl m_t=180 gev with non-standard br	pythia --- v01-01-37 --- top --- t+t --- incl_BR.n
95050	approved	top	mackin	5	200000	p20 pythia t+t->incl m_t=180 gev with non-standard br	pythia --- v01-01-37 --- top --- t+t --- incl_BR.n
95049	approved	top	mackin	5	200000	p20 pythia t+t->incl m_t=180 gev with non-standard br	pythia --- v01-01-37 --- top --- t+t --- incl_BR.n

Production System

- Request in the form of a Python dictionary

```
Request_94775({
        'requestId' : 94775L,
      'requestType' : 'simulation',
     'requestStatus' : 'new',
          'archive' : SamBoolean('FALSE'),
         'comments' : 'pythia hl+b->bb+b m_hl=100 gev',
            'group' : 'higgs',
    'numberOfEvents' : 150000L,
         'priority' : 5L,
     'statusHistory' :
RequestStatusHistory([RequestStatusHistoryEntry({
           'byWhom' : UserIdentifier(userName='mackin'),
             'date' : SamTime(1227540201.0),
    'requestStatus' : 'new',
    })]),
    'userIdentifier' : UserIdentifier(userName='mackin'),
          'params' : Params({
          'global' : CaseInsensitiveDictionary({
          'datatier' : 'reconstructed',
       'description' : 'Pythia hl+b->bb+b m_hl=100 GeV',
         'groupname' : 'higgs',
            'phase' : 'mcp20',
    'producedforname' : 'mackin',
         'requestid' : '94775',
          'runtype' : 'Monte Carlo',
           'stream' : 'notstreamed',
    }),
       'digitized' : CaseInsensitiveDictionary({
    'calorimeternoise' : 'off',
          'd0release' : 'p20.09.03',
    'frameworkrcpname' : 'runD0Sim_noCalNoise_run2b.rcp',
       'mergeminbias' : 'on',
       'minbidataset' :
'zerob_p20_09_03_RunIIbMC_online_0sup_only_sample_sept06_shutdown2007_warmcellfix',
           'minbiopt' : 'Fixed',
           'numminbi' : '1.0',
    }),
       'generated' : CaseInsensitiveDictionary({
       'cardfiledir' : 'higgs',
    'cardfileversion' : 'v01-01-00',
    'collisionenergy' : '1960.0',
         'd0release' : 'p20.09.03',
            'decay' : '3b_sm.n',
            'etagt' : '-5.0',
            'etalt' : '5.0',
         'generator' : 'pythia',
        'higgslmass' : '100.0',
        'pdflibfunc' : 'LHPDFCTEQ6L1',
        'production' : 'hl+b',
             'ptgt' : '15.0',
             'ptlt' : '-1.0',
          'topmass' : '170.0',
        'useevtgen' : 'on',
    }),
    'reconstructed' : CaseInsensitiveDictionary({
          'appfamily' : 'reconstruction',
           'appname' : 'd0reco',
         'appversion' : 'p20.09.03',
          'd0release' : 'p20.09.03',
    'frameworkrcpname' : 'runD0reco_mc.rcp',
    }),
       'simulated' : CaseInsensitiveDictionary({
             'd0release' : 'p20.09.03',
              'geometry' : 'plate-run2b',
    'keepparticlecalenergy' : 'off',
    }),
    }),
    })
```

MC Applications

- Typical request has 4 phases – 1 appl. each
  - Generator – physics of interest is created
  - Simulator – propagation of particles of interest through the detector
  - Digitizer – Put simulated data in the form of raw data and overlay with generic background
  - Reconstruction – Reconstruct with first pass data analysis code
- Metadata of all phases saved in SAM
  - Typically only the output of the last phase is saved on tape at FNAL

MC Grid Job Data Flow

- Bootstrap executable from Exec/Fwd node 3MB
- Initial environment/utility files from Exec/Fwd node 20MB
- Applications and execution environment from SAM cache (local or remote) 800MB
- Optional input data file, overlay files from SAM cache 200MB-1GB + 300MB
- For OSG or LCG jobs no VO specific pre-installed software required at the job site
- Output data file stored in “durable location” until merged

MC Grid Job Flow

- SAMGrid jobs are broken into 250 event chunks at the Exec/Fwd node for submission to the batch/Condor_g/Glite system
  - Execution time trade-off to maximize usable sites
- Output file size too small for efficient tape storage (20-30MB)
  - Merged in separate grid job
- The 10k event merged files (1GB) are stored on tape via SAM and unmerged files are deleted.

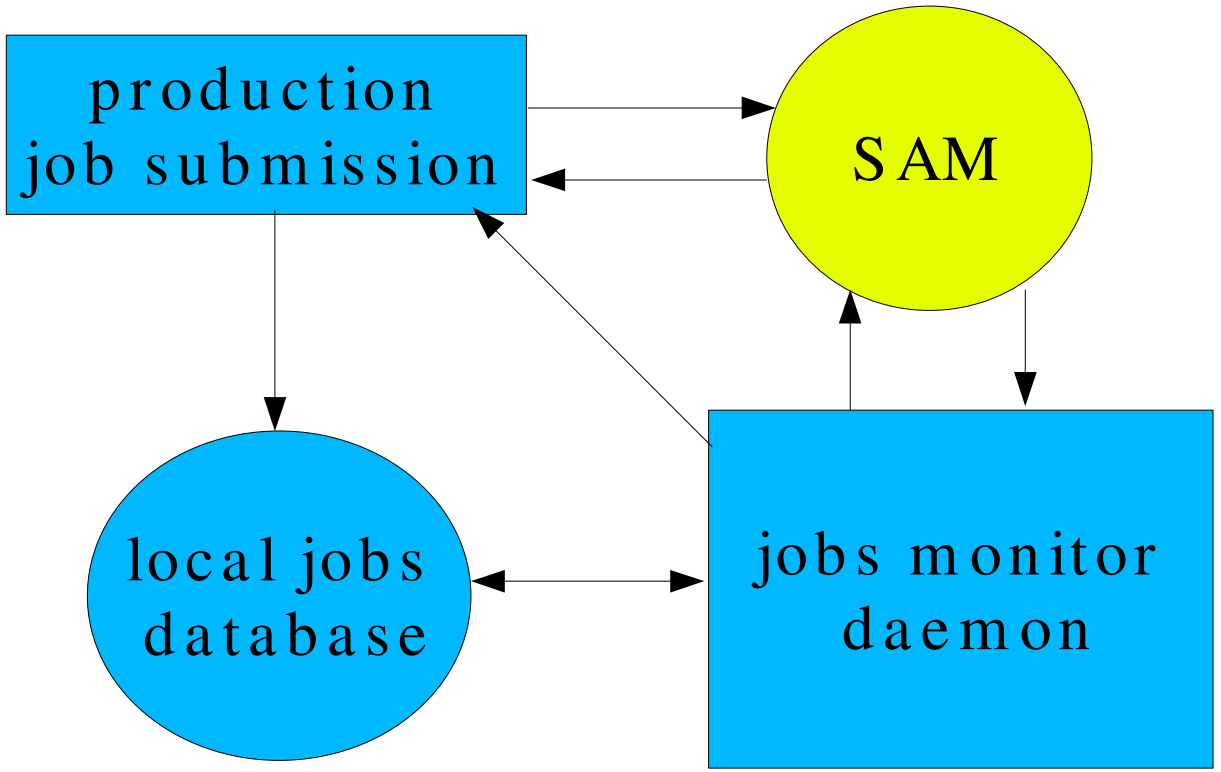
Automatic Monte Carlo Request Processing

- From approved request to final data storage
- Easy to use – minimizes manpower needs
- Site independent
  - deploy for any grid site (SAMGrid, OSG, LCG)
  - capable of managing many sites
- Handle recovery of common failures
- Integrate with existing MC request priority protocol

Auto MC System Components

- SAM Client for DB queries
- JIM for job submission and monitoring
  - jim_client package and dependencies
- Daemon
  - periodically awakens to do work
- Local database
  - request processing data and history
- Grid credentials

“Auto” MC Job Management Schematic



Daemon Components

- “Broker” assigns requests to resources
  - submits initial job of request
  - configured via text file
  - can pass site decision to other brokers
    - e.g. OSG ReSS
- Running request monitor
  - finishes production and merging
- Request status publisher
  - details in log files
  - summary on web page

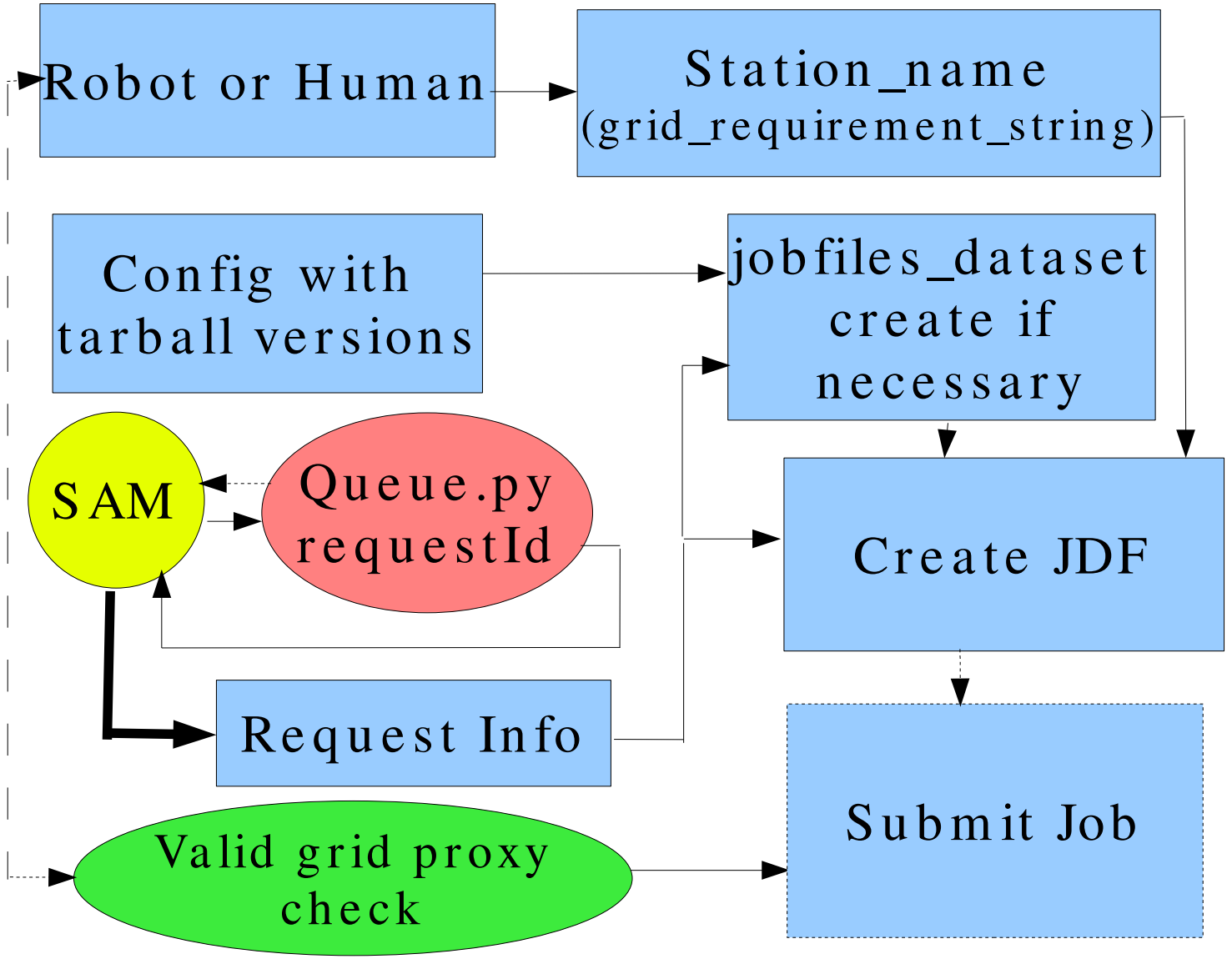
Jobs Database

- Persistent job info in simple Python object
  - key: requestId
  - value: list of tuples – a tuple corresponds to a job
  - tuple: (gjid, jobtype, station, d0release, jobfiles_dataset, subtime, endtime)
- Job submission records job data to database
- Job monitoring daemon uses job database to submit recovery and merge jobs
- Access uses file locking via a wrapper class
- Local to submitter

User Defined Application Data

- Configuration in text files
- Broker site capacity quotas (requests, events) and event throttle
- Info to create job file tarballs
  - read by daemon via http from central file
- Daemon run parameters - optional
- Skip processing problematic requests and jobs until resolution

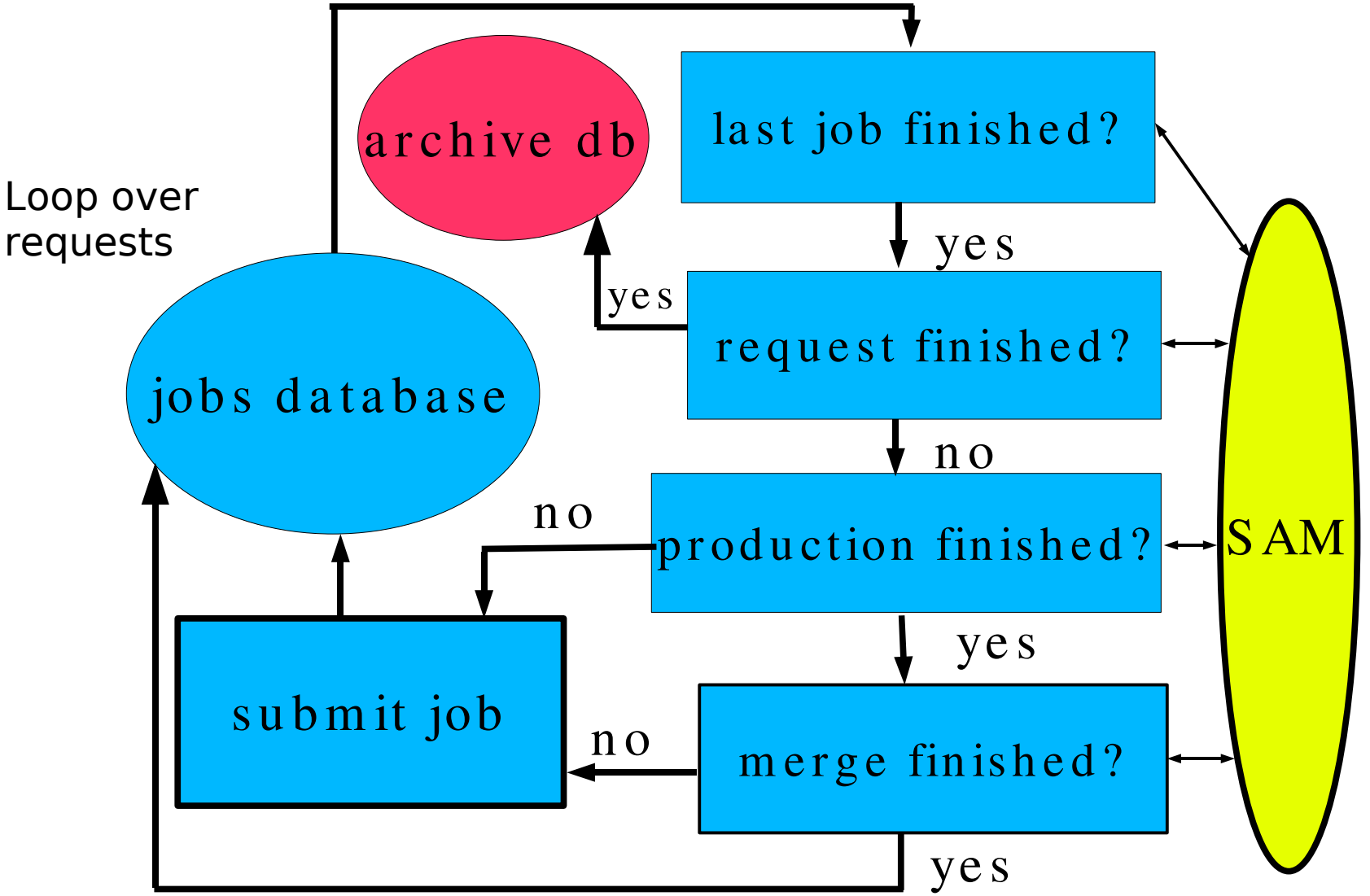
Job Submission Diagram



Job Monitor Daemon

- Daemon awakens periodically to check job DB
  - loops over requests
- Determines if last job is still running
  - if yes go to next request
- If not determines if request is finished
  - if yes archive request
- If production not finished, submit production recovery
- If production finished, submit merge
- If merge not finished, submit merge recovery

Job Monitor Daemon Diagram



AutoMC Monitoring

Running at FNAL & managing production at 26 sites

DAJD Status On Host d0mino03

Sat 29 Nov 2008 13:18:06 CST

51 running jobs
8 idle jobs
1 waiting jobs
3 unknown jobs

0.25 Activity index
0.27 Merge ratio

Active								
Site	Request	Job	Events	Status	% Complete	% Delta	No Change Hours	Active GJID
alicenext	94340	1	150250	running	101.9	0.0	1.3	(BS) snow_d0mino03.fnal.gov_053719_7210
	94348	1	132250	running	47.1	0.1	0.0	(BS) snow_d0mino03.fnal.gov_090835_25769
d0karlsruhe_v7	93917	1	210000	idle	0.0	0.0	13.4	(BS) snow_d0mino03.fnal.gov_130406_32150
	93918	1	210000	idle	0.0	0.0	12.2	(BS) snow_d0mino03.fnal.gov_130527_32217
	93921	1	210000	idle	0.0	0.0	6.9	(BS) snow_d0mino03.fnal.gov_130839_32322
	94784	15	merge	waiting	0.0	0.0	5.5	(BS) snow_d0mino03.fnal.gov_074418_3626
d0ustc	93720	3	merge	running	54.5	0.0	26.4	(BS) snow_d0mino03.fnal.gov_104438_3775
	94775	1	merge	running	0.0	0.0	17.4	(BS) snow_d0mino03.fnal.gov_194746_21098
	94792	0	157500	running	70.8	2.3	0.0	(BS) snow_d0mino03.fnal.gov_063740_13910
luhep	94224	2	29750	running	87.6	0.2	0.0	(BS) snow_d0mino03.fnal.gov_234703_10164
antaeus.hpcc.ttu.edu	93416	7	25000	running	66.2	0.4	0.0	(BS) snow_d0mino03.fnal.gov_154003_6500
caps10.phys.latech.edu	93734	1	25000	running	21.2	0.0	1.3	(BS) snow_d0mino03.fnal.gov_010100_27325
ce01.cmsaf.mit.edu	94752	5	24250	running	61.5	0.0	4.0	(BS) snow_d0mino03.fnal.gov_091413_31606
cit-gatekeeper.ultralight.org	93581	21	merge	running	20.0	0.0	143.5	(BS) snow_d0mino03.fnal.gov_001458_32727
	93731	0	25000	running	8.5	0.0	2.7	(BS) snow_d0mino03.fnal.gov_235821_23178
cmsosgce3.fnal.gov	94780	1	merge	running	6.7	6.7	0.0	(BS) snow_d0mino03.fnal.gov_103339_7538
	94833	0	25000	running	41.0	41.0	0.0	(BS) snow_d0mino03.fnal.gov_074733_3915
	94836	0	25000	idle	0.0	-	0.0	(BS) snow_d0mino03.fnal.gov_131642_372
condor1.oscer.ou.edu	94760	1	merge	running	0.0	0.0	4.0	(BS) snow_d0mino03.fnal.gov_090924_10580

Data Transport Issues

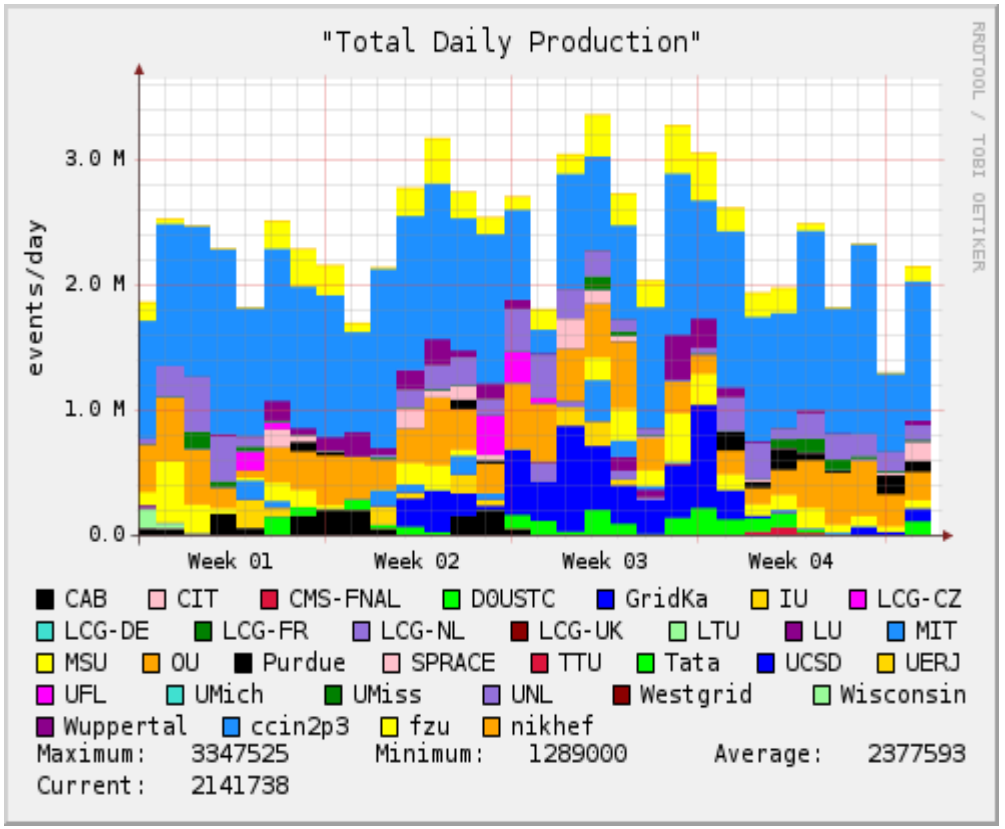
- SAMGrid uses LAN transport to workers from usually reliable SAM station caches
- OSG & LCG jobs use WAN transport to workers from remote SAM caches
  - Blessing: No VO specific software pre-installed at job site – great site selection flexibility
  - Curse: WAN transport less reliable than LAN
    - Less than optimum job efficiencies
- Use of local OSG SE's as SAM caches mitigates problem
  - SE's in use at IU, MSU, Purdue, UCSD, UNL
  - significant improvement in efficiency seen

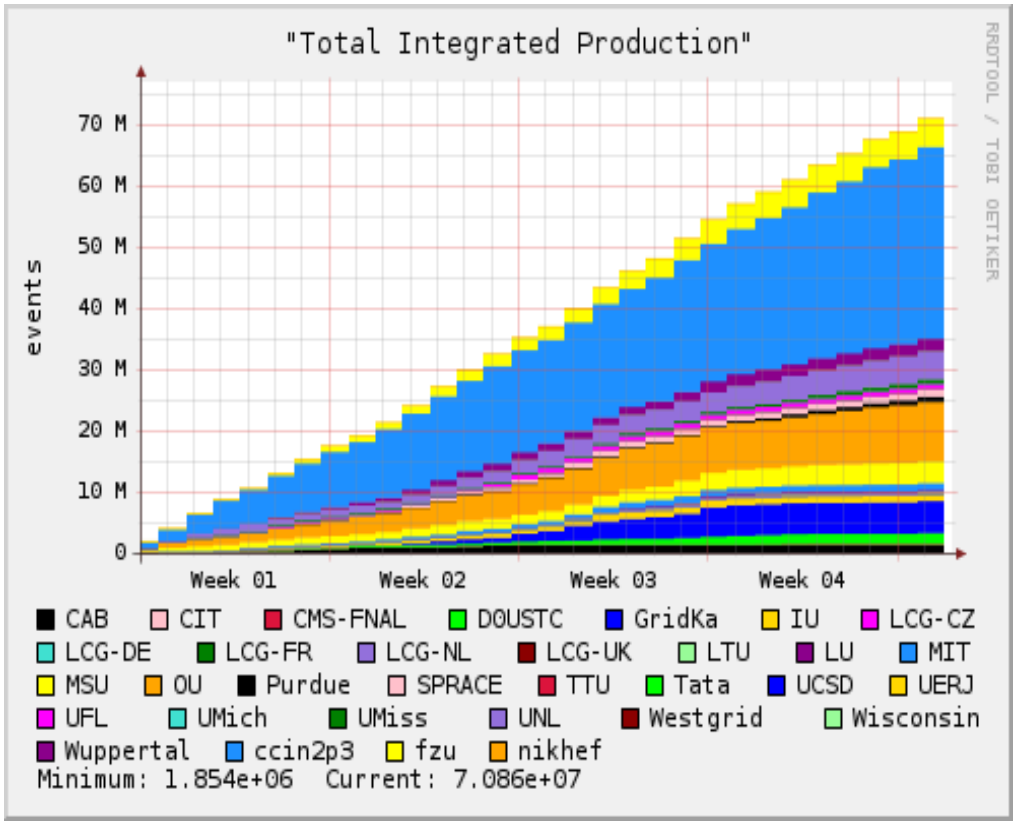
Production System Resources

- MC production uses a variety of dedicated and opportunistic resources on 4 continents
  - 1 Non-grid site at ccin2p3 Lyon (FR) – productive, flexible
  - Native Samgrid sites: FZU (CZ), GridKa (DE), LUHEP (US), USTC (CN), Wuppertal (DE)
  - LCG resources – CE's in FR, NL & UK, Samgrid-LCG infrastructure in FR, UK, NL, & DE
  - OSG resources – CE's, SE's, and Samgrid-OSG infrastructure in US & BR

MC Production Results

30 days
December 29, 2008 – January 27, 2009

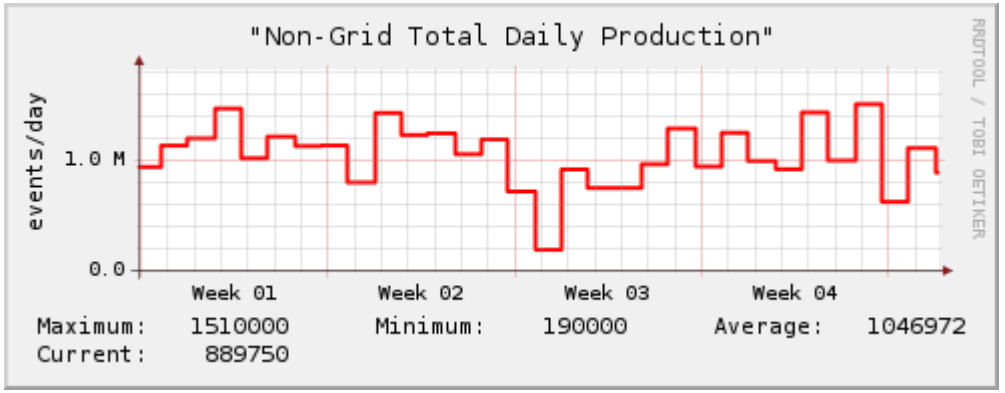


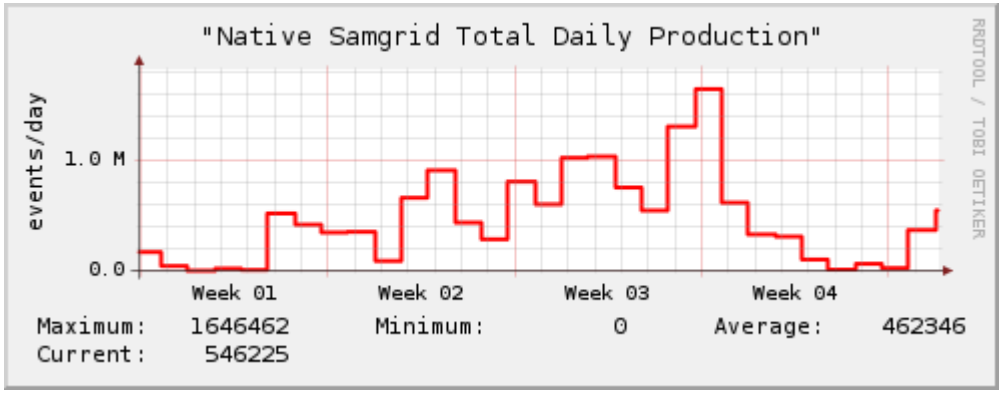


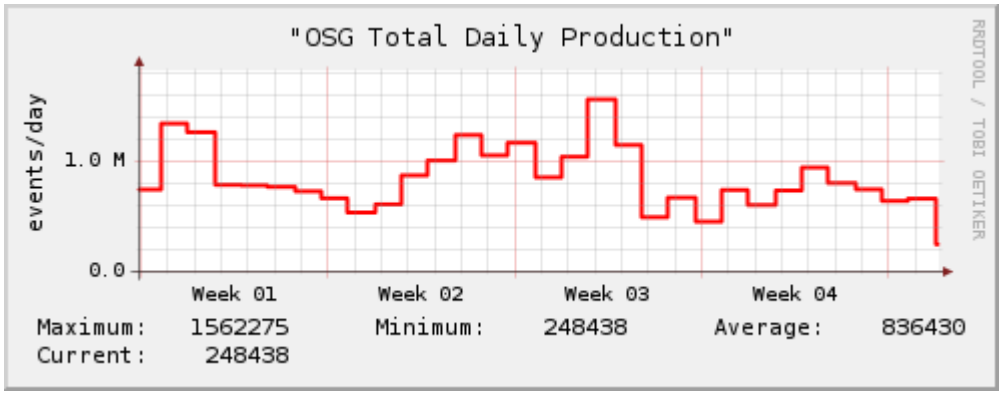
Averaging 2.4M events per day
Totaling 70.9M events in 30 days

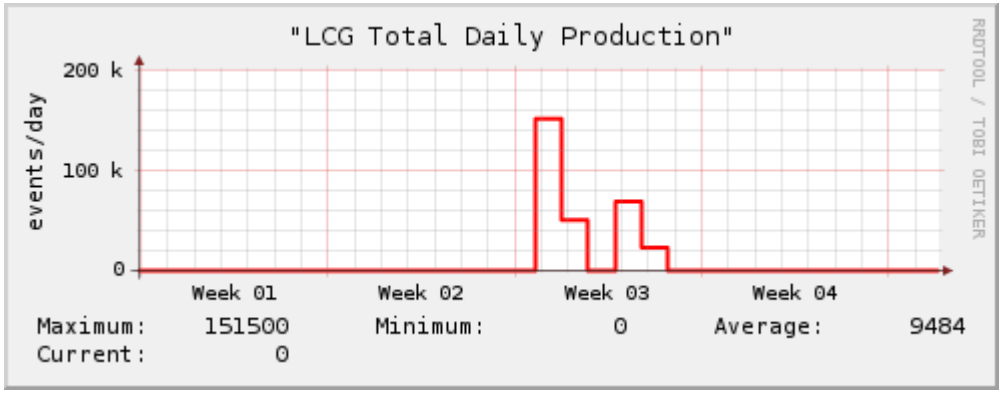
Production Results

30 days by production segment
December 29, 2008 – January 27, 2009





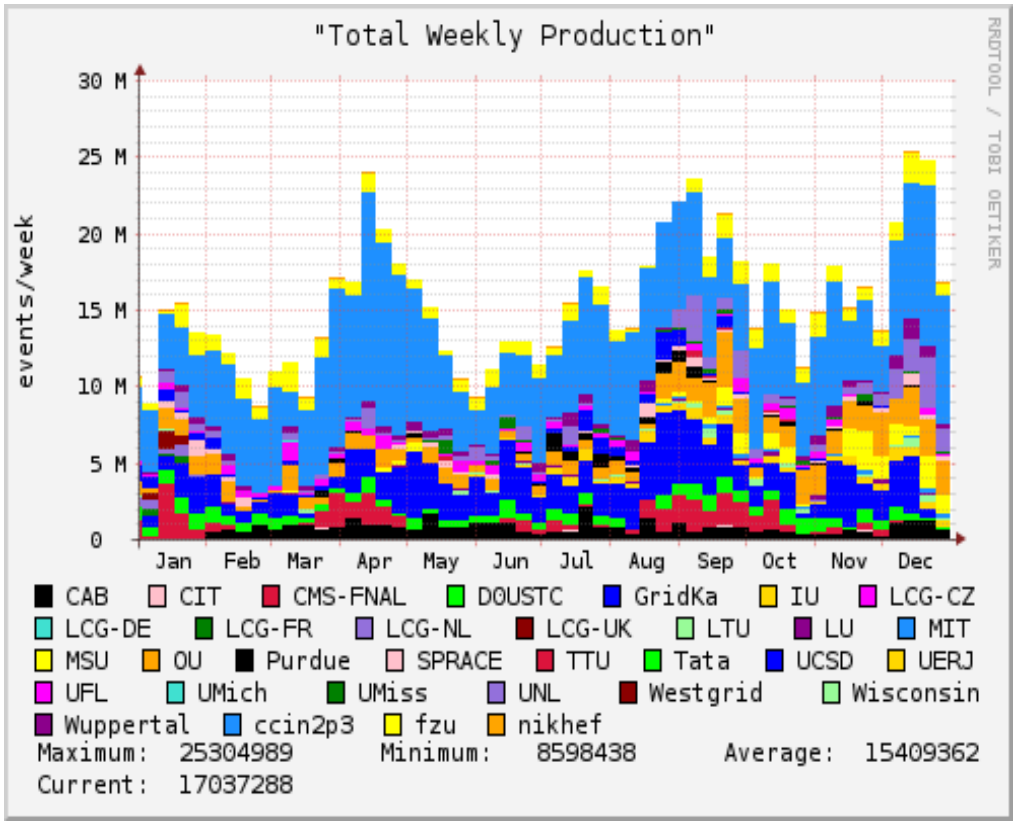




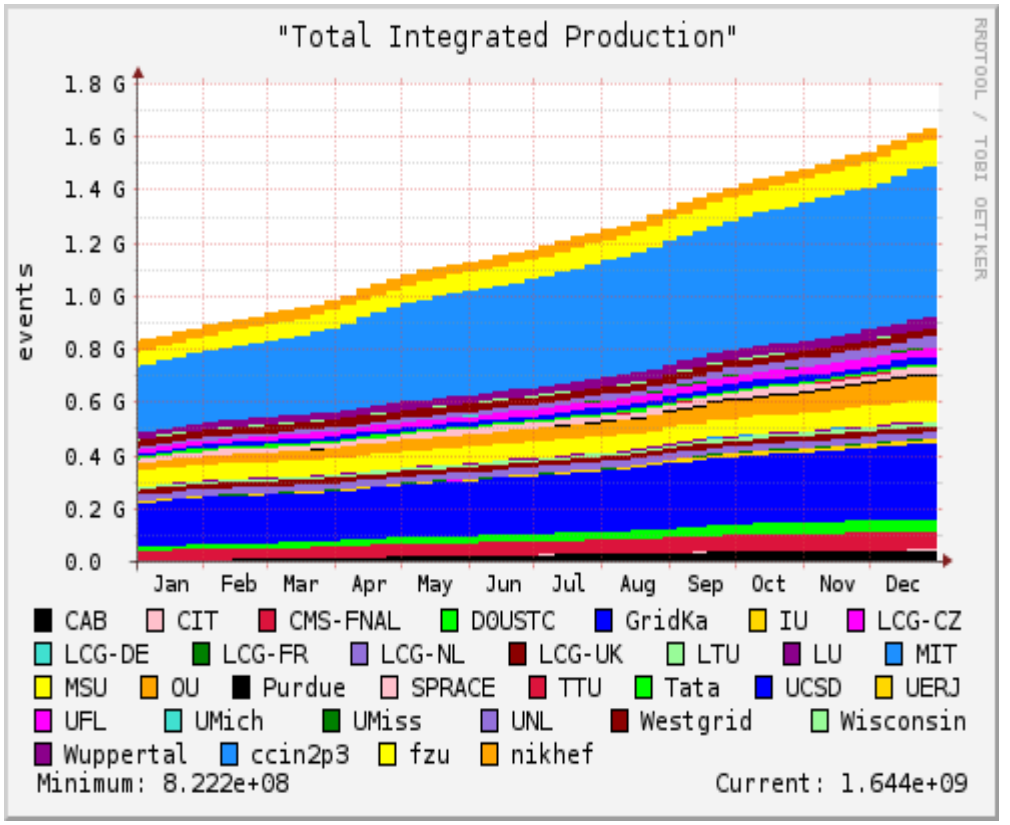
30 day averages per day
Non-grid: 1.05M, OSG: 836K, Samgrid: 462K, LCG: 9.5K

MC Production Results

Looking back at the last year



(2008/01/01 - 2009/01/01)

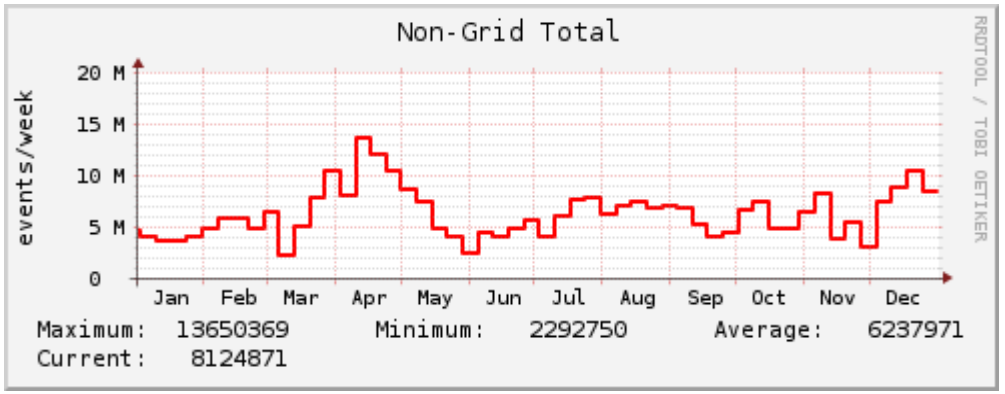


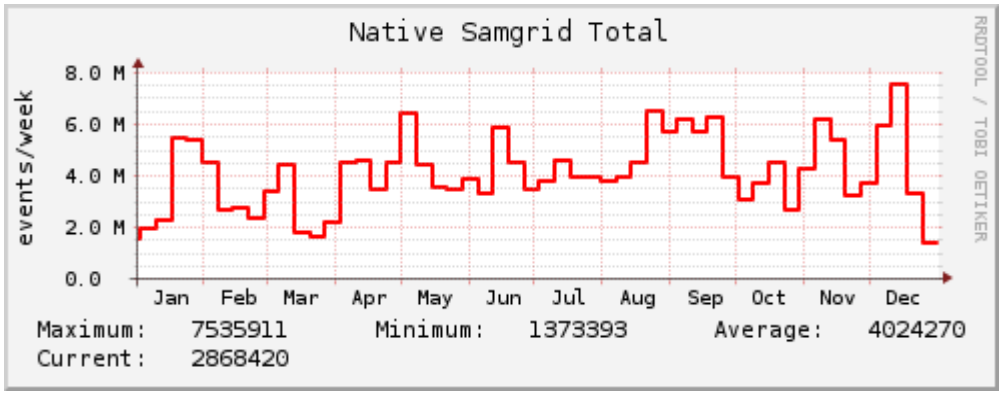
cumulative since September 2005.

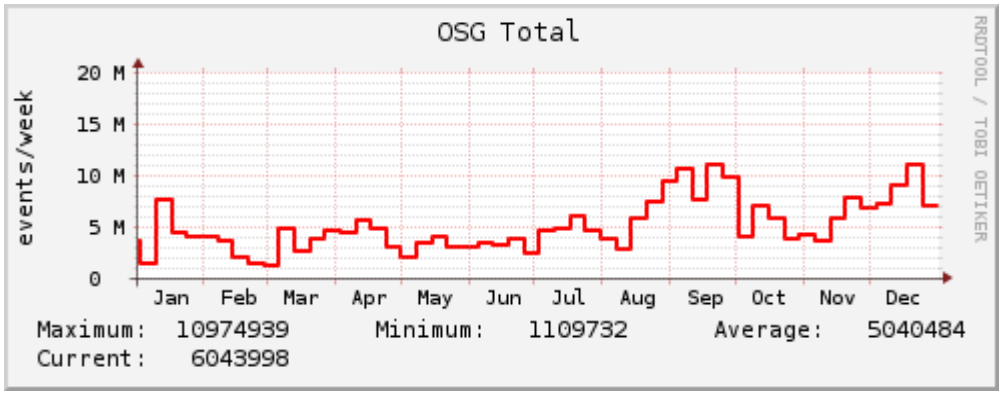
Averaging 15.5M per week and totaling 805M in a year

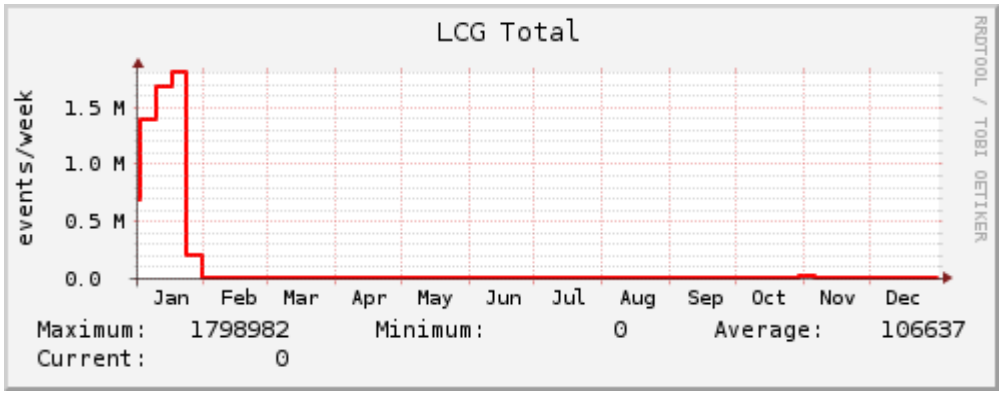
MC Production Results

Looking back at the last year by production segment







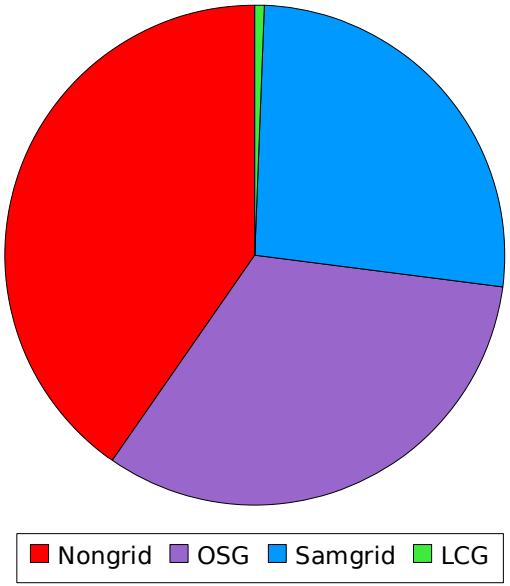


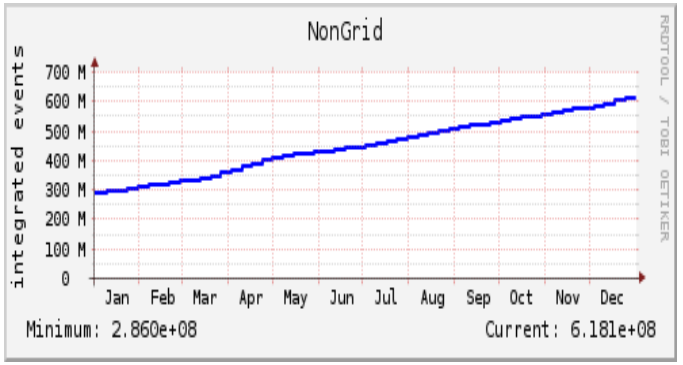
52 week averages events per week (2008/01/01 - 2009/01/01)
Non-grid: 6.24M, OSG: 5.04M, Samgrid: 4.02M, LCG: 0.11M

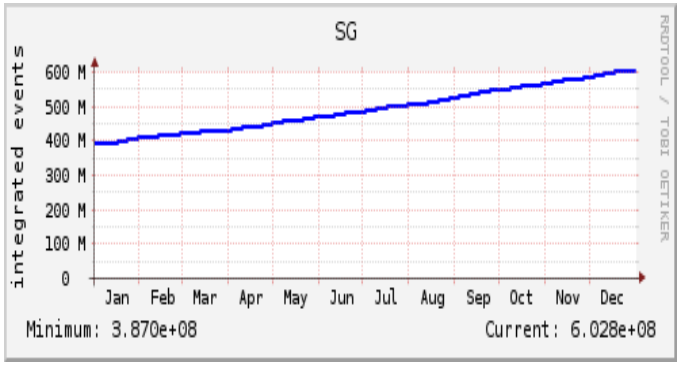
Production Results

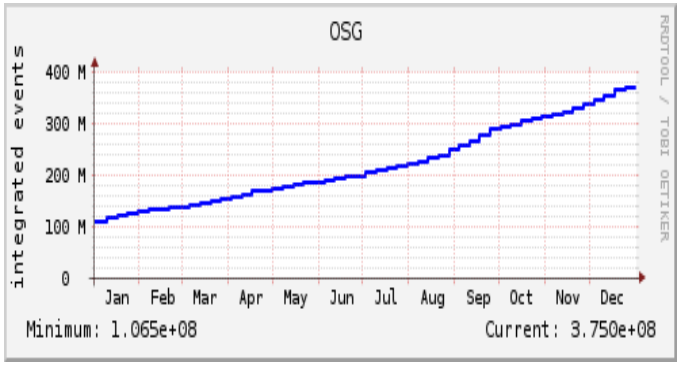
Looking back at the last year by production segment
Cumulative since September, 2005

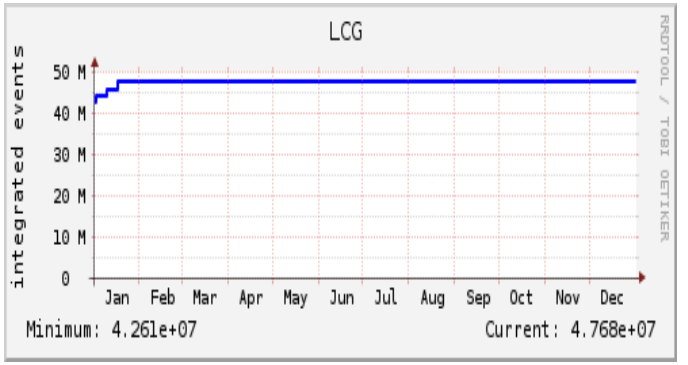
Production Last Year
By Segment











52 week event totals (2008/01/01 - 2009/01/01)

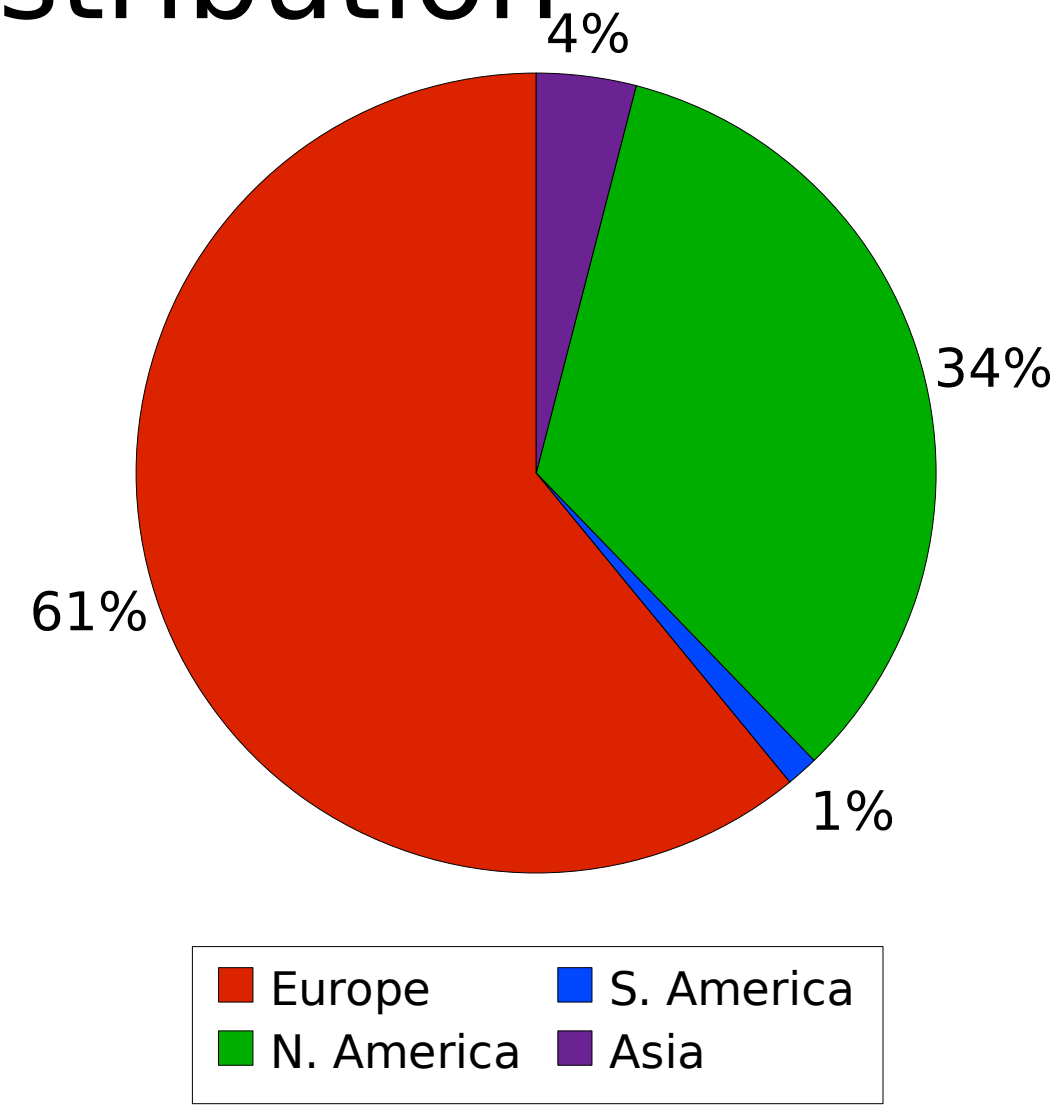
Non-grid: 324.4M, OSG: 262.8M, Samgrid: 212.9M, LCG: 5.0M

40.3% 32.6% 26.4% 0.6%

MC Production Geographic Distribution

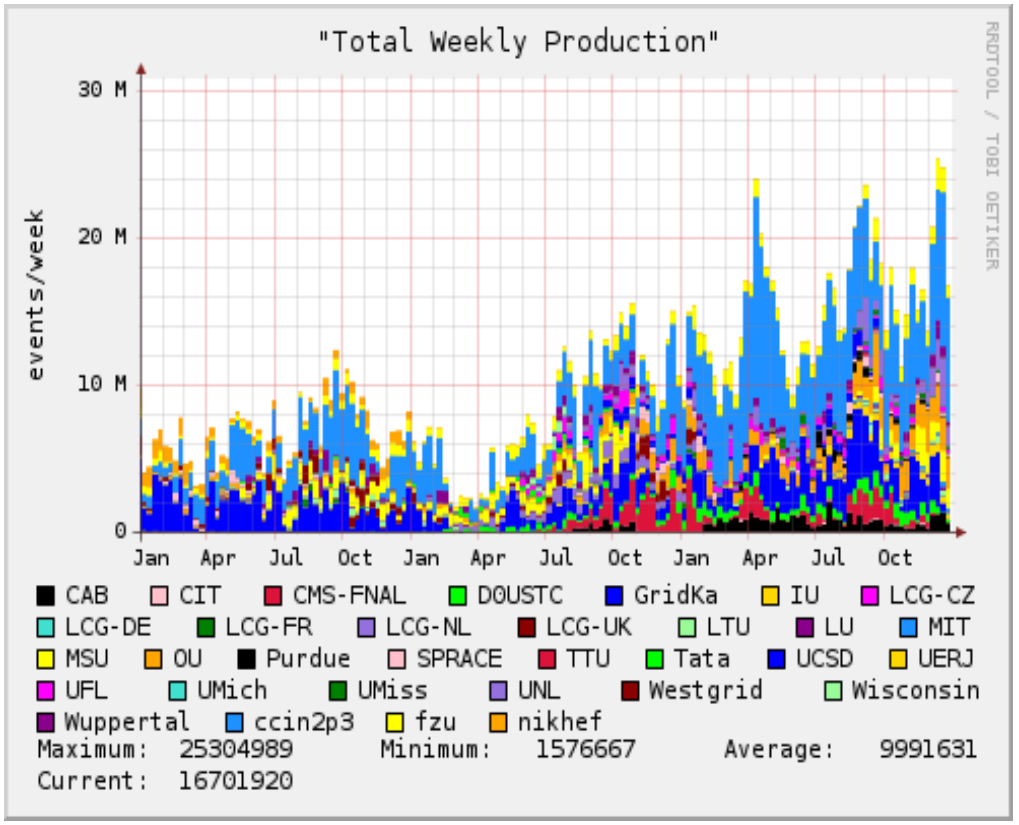
Events Last Year:	
Europe	483M
N. America	232M
Asia	34M
S. America	11M

(2008/01/01 - 2009/01/01)

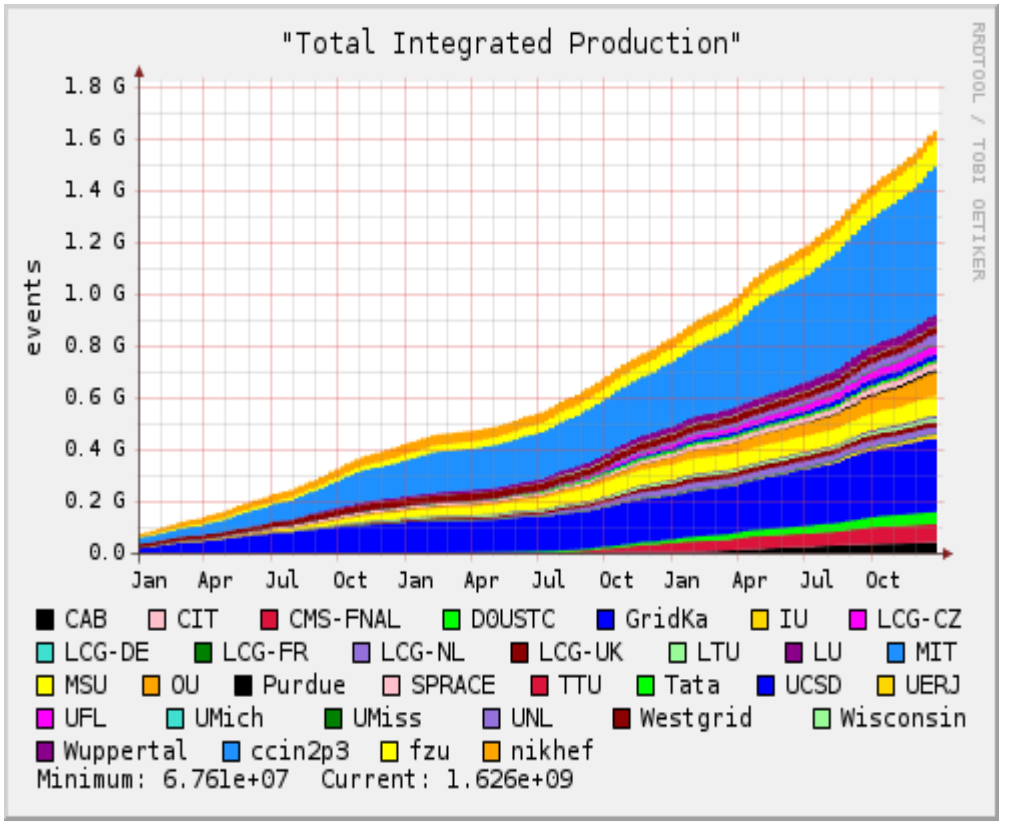


MC Production Results

Looking back at the last 3 years



(2006/01/01 - 2009/01/01)

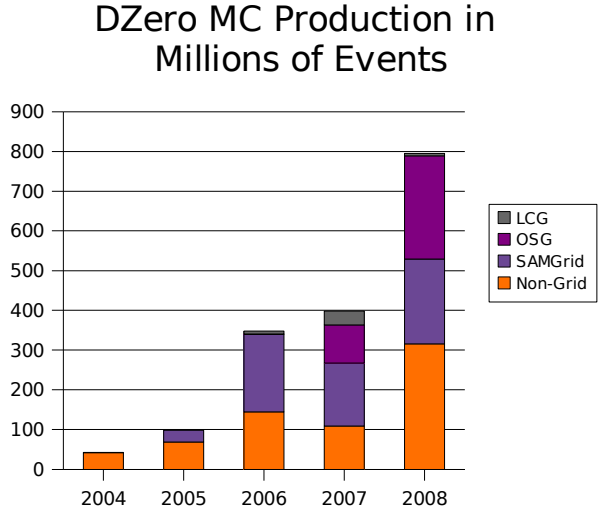


cumulative since September 2005.

Averaging 10M per week and totaling 1.5B in 3 years

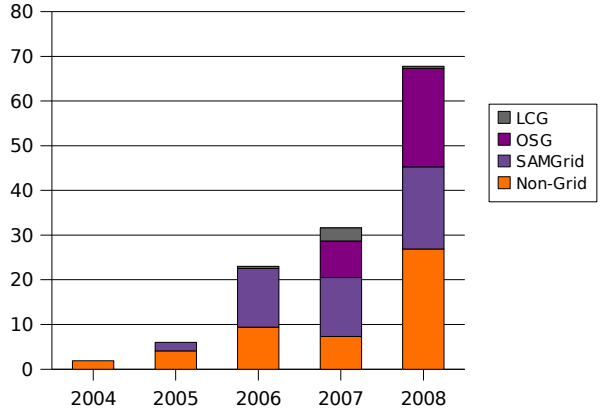
Production Results Last 5 Years

DZero MC Production in Millions of Events



Period	Total	Non-Grid	SAMGrid	OSG	LCG
2007/12/26-2008/12/26	794.8	315.6	213.6	259.7	5.8
2006/12/26-2007/12/26	398.2	109.1	158.1	96.5	34.4
2005/12/26-2006/12/26	348.0	144.4	195.5	0.5	7.6
2004/12/26-2005/12/26	98.1	68.6	29.5	0.0	0.0
2003/12/26-2004/12/26	42.4	41.8	0.6	0.0	0.0

DZero MC Production in Terabytes of Data

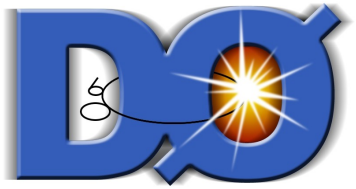


Period	Total	Non-Grid	SAMGrid	OSG	LCG
2007/12/26-2008/12/26	67.8	26.9	18.4	22.0	0.5
2006/12/26-2007/12/26	31.6	7.3	13.2	8.2	2.9
2005/12/26-2006/12/26	23.0	9.4	13.1	0.0	0.5
2004/12/26-2005/12/26	6.0	4.1	1.9	0.0	0.0
2003/12/26-2004/12/26	1.9	1.9	0.0	0.0	0.0

Future Prospects

- Nongrid and native SAMGrid will not expand appreciably if at all
- Diminishing job slots on opportunistic resources as LHC data flows
- What's to be done?
  - Have not yet exhausted all possible OSG resources
  - LCG resources will be usable again
    - Additional 25% of production capacity possible
  - Are other grids usable? exploring Teragrid use
- How well are existing resources being used?

Summary

-  's early deployment of grid technology and automation has dramatically increased MC production
  - First deployment SAM distributed data handling system
  - Early SAMGrid deployment
  - Use of OSG and LCG resources through interoperability with SAMGrid
  - First opportunistic usage of OSG Storage Elements
  - Automated MC production system

Conclusion

- MC production doing well – rate doubled in last year despite no appreciable LCG production for 12 months
- Probably facing future resource diminution
- Efforts underway to help sustain production
  - Increase opportunistic computing and storage
  - Increase job efficiency
  - Minimize faulty requests reaching the system
  - Increase infrastructure resiliency
  - Exploring new resources including Teragrid via interoperability with OSG