Managing data movement between OSG sites in ATLAS experiment

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Annual OSG Users Meeting'08

Outline

- ATLAS Event Model
- Distributed Data Management (DDM) software and components
- DDM Operation Activity
  - Data replication tests
    - CCRC08, FDR-II, Functional Tests
- Conclusions and summary

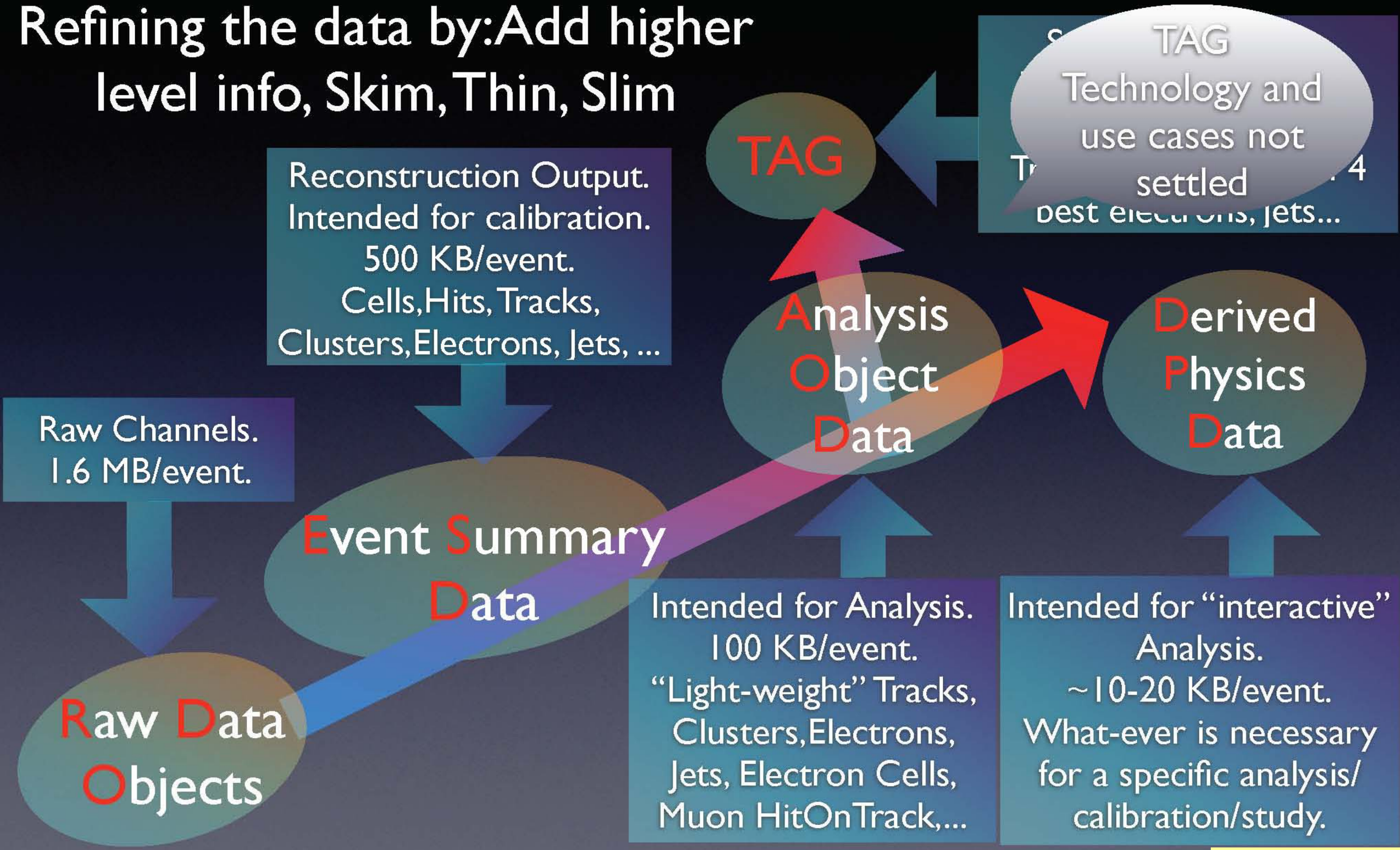
Event data flow from online to offline

- Events are written in “ByteStream” format by the Event Filter farm in ~2 GB files
  - ~1000 events/file (nominal size is 1.6 MB/event)
  - 200 Hz trigger rate (independent of luminosity)
  - Currently several streams are foreseen:
    - Express stream with “most interesting” events to be processed immediately
    - ~5 event streams, separated by trigger signature
      - e.g. muons, electromagnetic, hadronic jets, taus, minimum bias
    - Calibration events
    - “Trouble maker” events (for debugging)
  - One 2-GB file every 5 seconds will be available from the Event Filter
  - Data will be transferred from the pit to the Tier-0 input buffer at 320 MB/s (average)

from D.Barberis

The Event Data Model

Refining the data by:Add higher level info, Skim, Thin, Slim



TAG

S

Tr

4

best electrons, jets...

TAG
Technology and use cases not settled

Reconstruction Output.
Intended for calibration.
500 KB/event.
Cells, Hits, Tracks, Clusters, Electrons, Jets, ...

Raw Channels.
1.6 MB/event.

Raw Data Objects

Event Summary Data

Analysis Object Data

Derived Physics Data

Intended for Analysis.
100 KB/event.
"Light-weight" Tracks, Clusters, Electrons, Jets, Electron Cells, Muon HitOnTrack,...

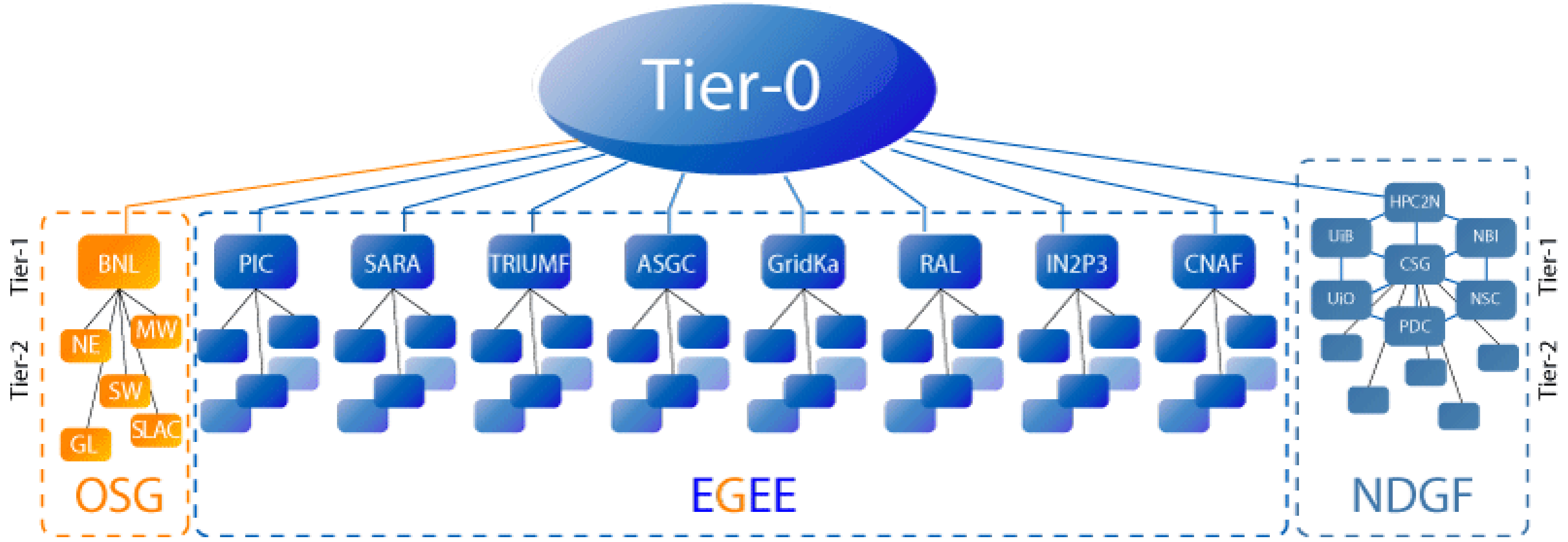
Intended for "interactive" Analysis.
~10-20 KB/event.
What-ever is necessary for a specific analysis/calibration/study.

A.Farbin/UTA

Event data model

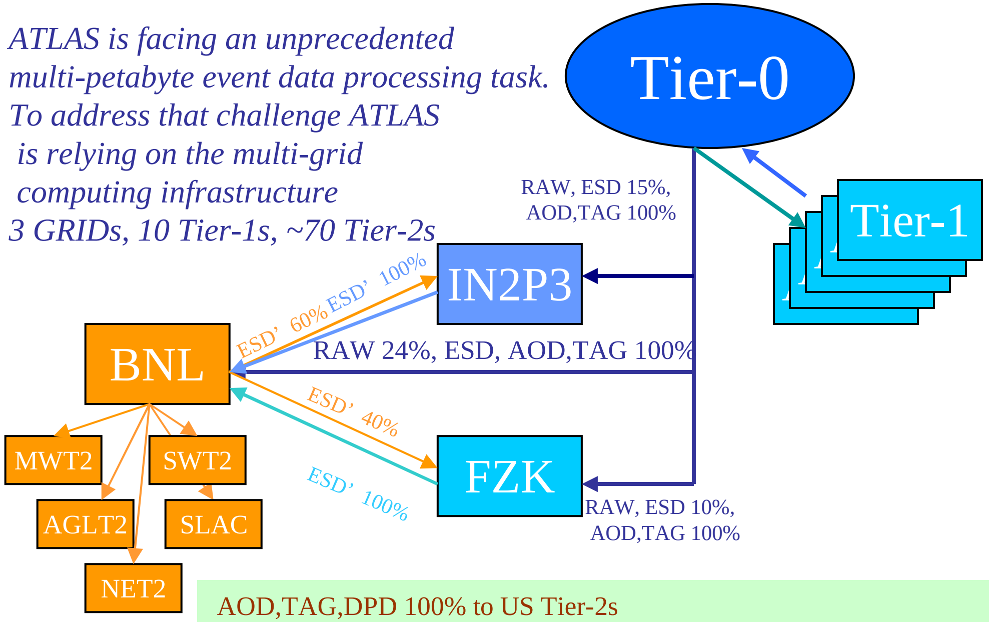
- RAW:
  - “ByteStream” format, ~1.6 MB/event
- ESD (Event Summary Data):
  - Full output of reconstruction in object (POOL/ROOT) format:
    - Tracks (and their hits), Calo Clusters, Calo Cells, combined reconstruction objects etc.
  - Nominal size 1 MB/event initially, to decrease as the understanding of the detector improves
    - Compromise between “being able to do everything on the ESD” and “not enough disk space to store too large events”
- AOD (Analysis Object Data):
  - Summary of event reconstruction with “physics” (POOL/ROOT) objects:
    - electrons, muons, jets, etc.
  - Nominal size 100 kB/event (now 200 kB/event including MC truth)
- DPD (Derived Physics Data):
  - Skimmed/slimmed/thinned events + other useful “user” data derived from AODs and conditions data
  - Nominally 10 kB/event on average
    - Large variations depending on physics channels
- TAG:
  - Database (or ROOT files) used to quickly select events in AOD and/or ESD files

from D.Barberis



ATLAS is facing an unprecedented multi-petabyte event data processing task. To address that challenge ATLAS is relying on the multi-grid computing infrastructure

3 GRIDs, 10 Tier-1s, ~70 Tier-2s



AOD,TAG,DPD 100% to US Tier-2s
AOD',TAG' – reprocessed data , replicated to ALL ATLAS Tier-1s
ESD' - reprocessed data, replicated within "triangle" BNL-FZK-LYON

ATLAS Tier-0 expected average rates

- Raw 320 MB/s
- ESD 200 MB/s
- AOD 20 MB/s
- TAG 2 MB/s

Total : 542 MB/s from Tier-0 to Tier-1s

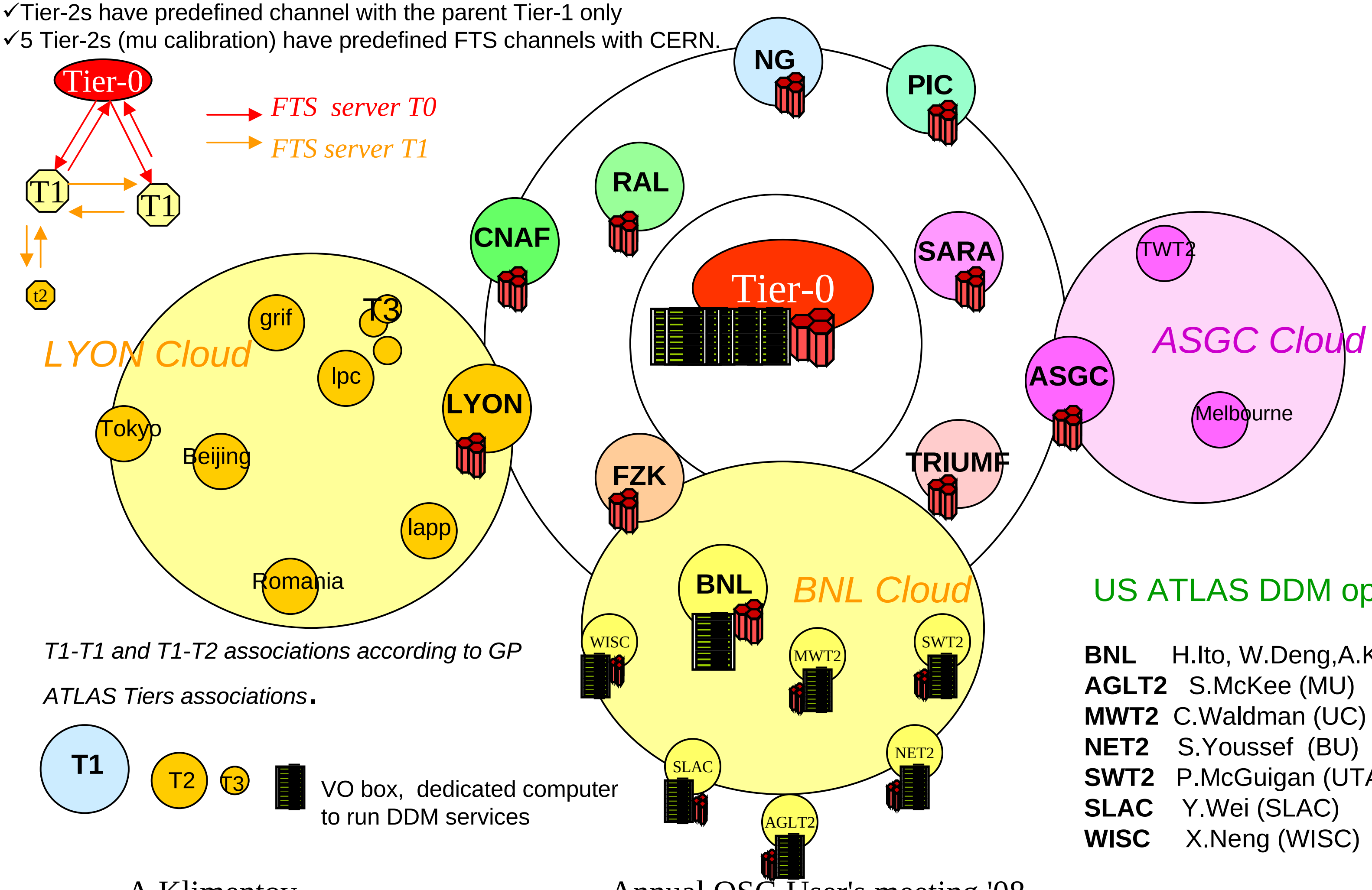
- BNL expected average rates (w/o re-processed data)
  - Tape
    - RAW 80 MB/s
  - Disk
    - ESD 50+150 MB/s
    - AOD 20 MB/s
    - TAG 2 MB/s

Total BNL : 302 MB/s

DDM Deployment and Operations Model

- ✓EGEE and NDGF clouds have 1 File Catalog (LFC) per cloud
- ✓US cloud has 1 file catalog (LRC) per site
- ✓All Tier-1s have predefined FTS channel with CERN and with each other.
- ✓Tier-2s are associated with one Tier-1 and form the cloud
- ✓Tier-2s have predefined channel with the parent Tier-1 only
- ✓5 Tier-2s (mu calibration) have predefined FTS channels with CERN.

DDM Deployment Model since Jun 2007



T1-T1 and T1-T2 associations according to GP ATLAS Tiers associations.

VO box, dedicated computer to run DDM services

US ATLAS DDM operations team :

BNL	H.Ito, W.Deng,A.Klimentov,P.Nevski
AGLT2	S.McKee (MU)
MWT2	C.Waldman (UC)
NET2	S.Youssef (BU)
SWT2	P.McGuigan (UTA)
SLAC	Y.Wei (SLAC)
WISC	X.Neng (WISC)

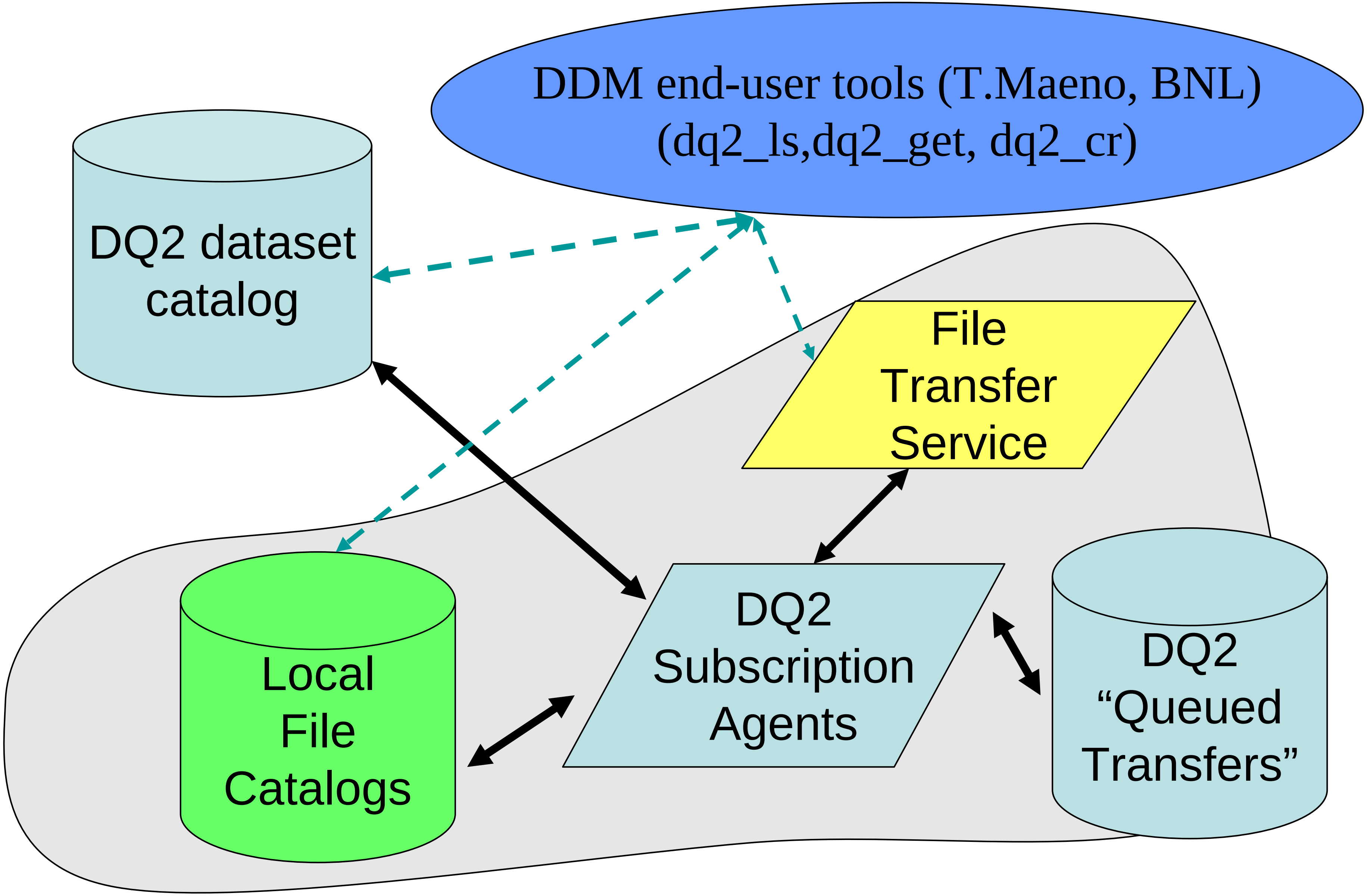
ATLAS Data Management Software - Don Quijote

- The second generation of the ATLAS DDM system (DQ2)
  - DQ2 developers M.Branco, D.Cameron, V.Garonne, T.Maeno(BNL), P.Salgado, T.Wenaus(BNL),…
  - Initial idea and architecture were proposed by M.Branco and T.Wenaus (BNL)
- DQ2 is built on top of Grid data transfer tools
  - Moved to *dataset* based approach
    - Datasets : an aggregation of files plus associated DDM metadata
    - Datasets is a unit of storage and replication
    - Automatic data transfer mechanisms using distributed site services
      - Subscription system
      - Notification system
  - SW releases deployed in 2007 /08
    - Central services : DQ2 0.3 (Jun 07)
    - Site Services : DQ2 0.4 (Oct 07)
    - Site Services : DQ2 0.5 (Dec 07)
    - Site Services : DQ2 0.6 (Mar-Apr 08)
    - Central catalogs, containers, site services : DQ2 1.0, 1.1 (May-Jun 08)

Major Changes and Improvements in DDM/DQ2 Software (2007/08)

- 6 Software release since Jun 2007 to address Operations needs and to improve system performance
  - Switch to ORACLE backend for central datasets catalog
    - Performance and stability are improved
  - [ARDA] Monitoring
    - Data navigation
    - Cloud views
    - Errors summary
  - Site services
    - Dataset replicas look up is improved
    - Dataset subscription processing is improved
  - New packaging and deployment procedures
  - Fair-share implementation
    - Used for critical data replication (conditions data, database releases, etc)
  - New central catalogs schema
  - Containers implementation

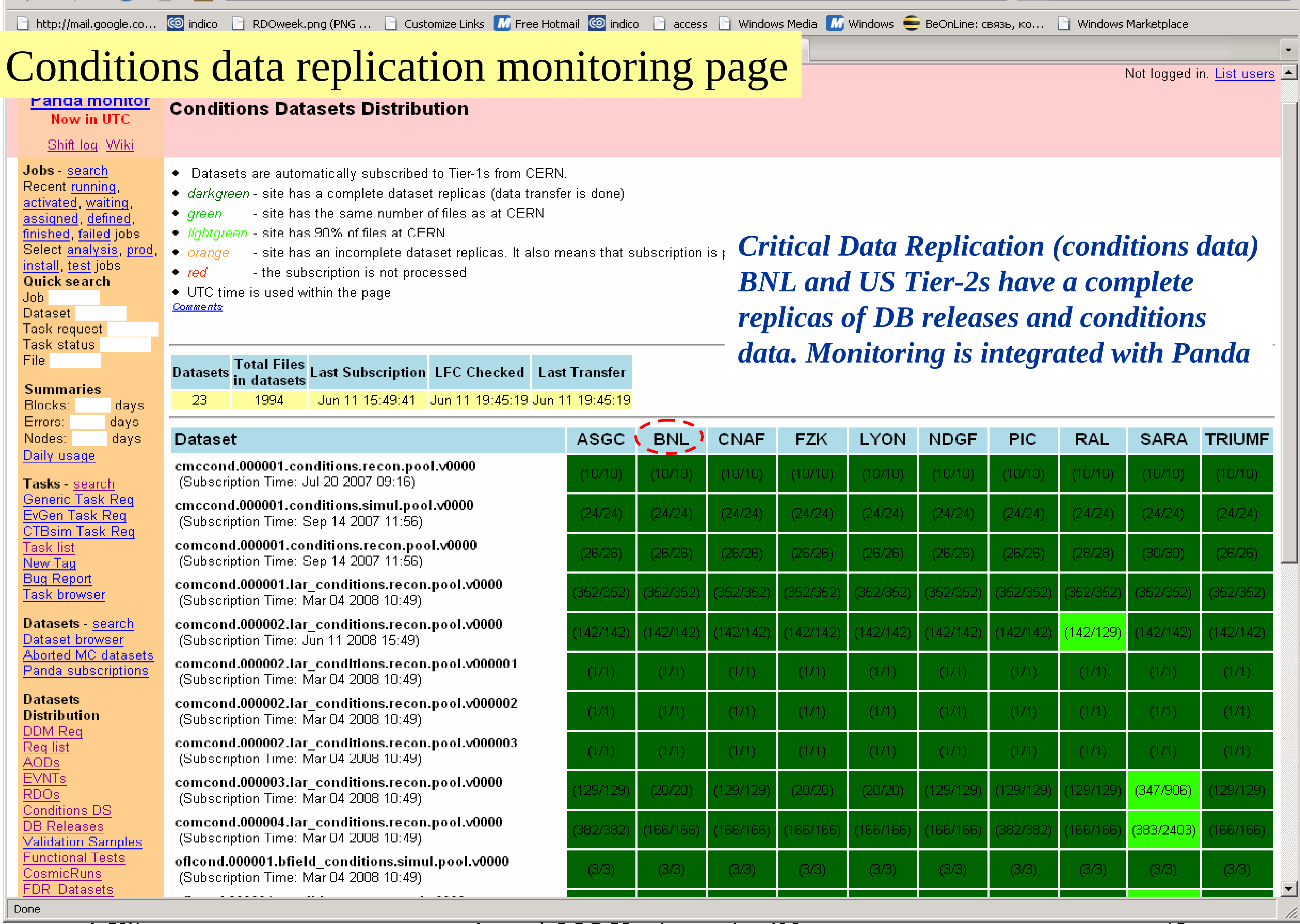
DDM components



DDM Activities.

- Cosmic data replication
- Critical data (conditions datasets, database releases) replication
- Analysis Object Data (AOD) replication for physics analysis
- Support MC production
- DDM monitoring and control
- Data integrity check
- DDM Functional and throughput tests
- User and group support

Conditions data replication monitoring page



Not logged in. List users

Panda monitor
Now in UTC

Shift log Wiki

Jobs - search
Recent running, activated, waiting, assigned, defined, finished, failed jobs
Select analysis, prod, install, test jobs

Quick search
Job
Dataset
Task request
Task status
File

Summaries
Blocks: days
Errors: days
Nodes: days
Daily usage

Tasks - search
Generic Task Req
EvGen Task Req
CTBsim Task Req
Task list
New Tag
Bug Report
Task browser

Datasets - search
Dataset browser
Aborted MC datasets
Panda subscriptions

Datasets Distribution
DDM Req
Req list
AODs
EVNTs
RDOs
Conditions DS
DB Releases
Validation Samples
Functional Tests
CosmicRuns
FDR Datasets

Conditions Datasets Distribution

- Datasets are automatically subscribed to Tier-1s from CERN.
- *darkgreen* - site has a complete dataset replicas (data transfer is done)
- *green* - site has the same number of files as at CERN
- *lightgreen* - site has 90% of files at CERN
- *orange* - site has an incomplete dataset replicas. It also means that subscription is p
- *red* - the subscription is not processed
- UTC time is used within the page

Comments

Datasets	Total Files in datasets	Last Subscription	LFC Checked	Last Transfer
23	1994	Jun 11 15:49:41	Jun 11 19:45:19	Jun 11 19:45:19

Dataset	ASGC	BNL	CNAF	FZK	LYON	NDGF	PIC	RAL	SARA	TRIUMF
cmccond.000001.conditions.recon.pool.v0000 (Subscription Time: Jul 20 2007 09:16)	(10/10)	(10/10)	(10/10)	(10/10)	(10/10)	(10/10)	(10/10)	(10/10)	(10/10)	(10/10)
cmccond.000001.conditions.simul.pool.v0000 (Subscription Time: Sep 14 2007 11:56)	(24/24)	(24/24)	(24/24)	(24/24)	(24/24)	(24/24)	(24/24)	(24/24)	(24/24)	(24/24)
comcond.000001.conditions.recon.pool.v0000 (Subscription Time: Sep 14 2007 11:56)	(26/26)	(26/26)	(26/26)	(26/26)	(26/26)	(26/26)	(26/26)	(28/28)	(30/30)	(26/26)
comcond.000001.lar_conditions.recon.pool.v0000 (Subscription Time: Mar 04 2008 10:49)	(352/352)	(352/352)	(352/352)	(352/352)	(352/352)	(352/352)	(352/352)	(352/352)	(352/352)	(352/352)
comcond.000002.lar_conditions.recon.pool.v0000 (Subscription Time: Jun 11 2008 15:49)	(142/142)	(142/142)	(142/142)	(142/142)	(142/142)	(142/142)	(142/142)	(142/129)	(142/142)	(142/142)
comcond.000002.lar_conditions.recon.pool.v000001 (Subscription Time: Mar 04 2008 10:49)	(1/1)	(1/1)	(1/1)	(1/1)	(1/1)	(1/1)	(1/1)	(1/1)	(1/1)	(1/1)
comcond.000002.lar_conditions.recon.pool.v000002 (Subscription Time: Mar 04 2008 10:49)	(1/1)	(1/1)	(1/1)	(1/1)	(1/1)	(1/1)	(1/1)	(1/1)	(1/1)	(1/1)
comcond.000002.lar_conditions.recon.pool.v000003 (Subscription Time: Mar 04 2008 10:49)	(1/1)	(1/1)	(1/1)	(1/1)	(1/1)	(1/1)	(1/1)	(1/1)	(1/1)	(1/1)
comcond.000003.lar_conditions.recon.pool.v0000 (Subscription Time: Mar 04 2008 10:49)	(129/129)	(20/20)	(129/129)	(20/20)	(20/20)	(129/129)	(129/129)	(129/129)	(347/906)	(129/129)
comcond.000004.lar_conditions.recon.pool.v0000 (Subscription Time: Mar 04 2008 10:49)	(382/382)	(166/166)	(166/166)	(166/166)	(166/166)	(166/166)	(382/382)	(166/166)	(383/2403)	(166/166)
oflcond.000001.bfield_conditions.simul.pool.v0000 (Subscription Time: Mar 04 2008 10:49)	(3/3)	(3/3)	(3/3)	(3/3)	(3/3)	(3/3)	(3/3)	(3/3)	(3/3)	(3/3)

Critical Data Replication (conditions data) BNL and US Tier-2s have a complete replicas of DB releases and conditions data. Monitoring is integrated with Panda

DDM Replication Metrica

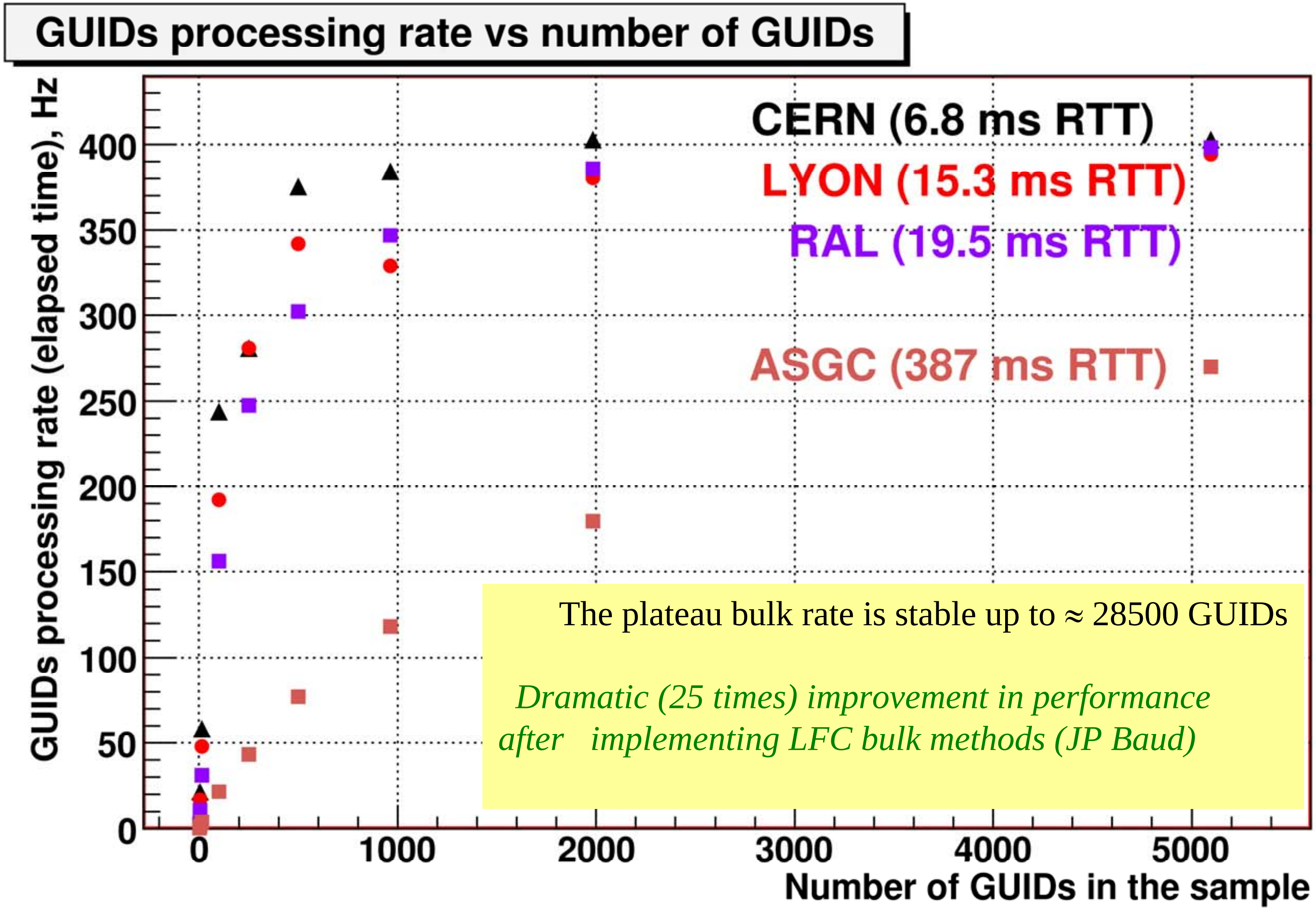
- Test Software Components
- Combined Computing Readiness Challenge of 2008
- Full Dress Rehearsal
- Functional and Throughput Tests

Test DDM SW Components. LFC

- LFC – one of vital components, out of DDM
- It is important the two work together as expected
- We organized systematic measurements to understand performance to spot and fix problems...
- Initial LFC performance was found poor : 12 Hz
- It was joint effort of ATLAS DDM Operations team, DQ2 developers, CERN ARDA and LFC Author to understand and to improve the catalog’s performance.
- ATLAS performance requirement was driven by our computing and event model

Test DDM SW Components

Results on Performance Testingof the LFC @ CERN



The plateau bulk rate is stable up to ≈ 28500 GUIDs

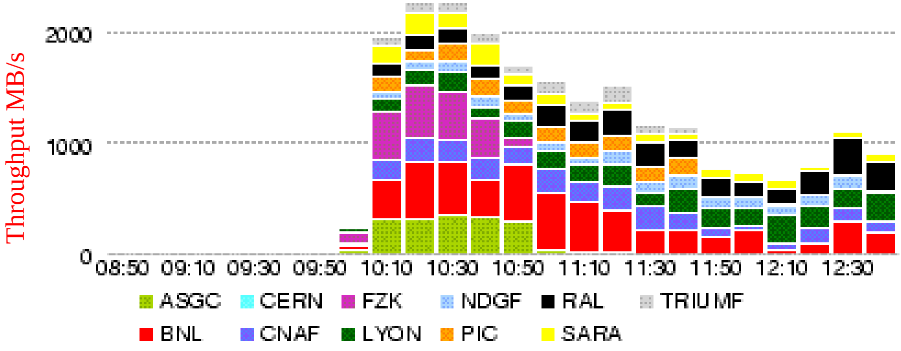
Dramatic (25 times) improvement in performance after   implementing LFC bulk methods (JP Baud)

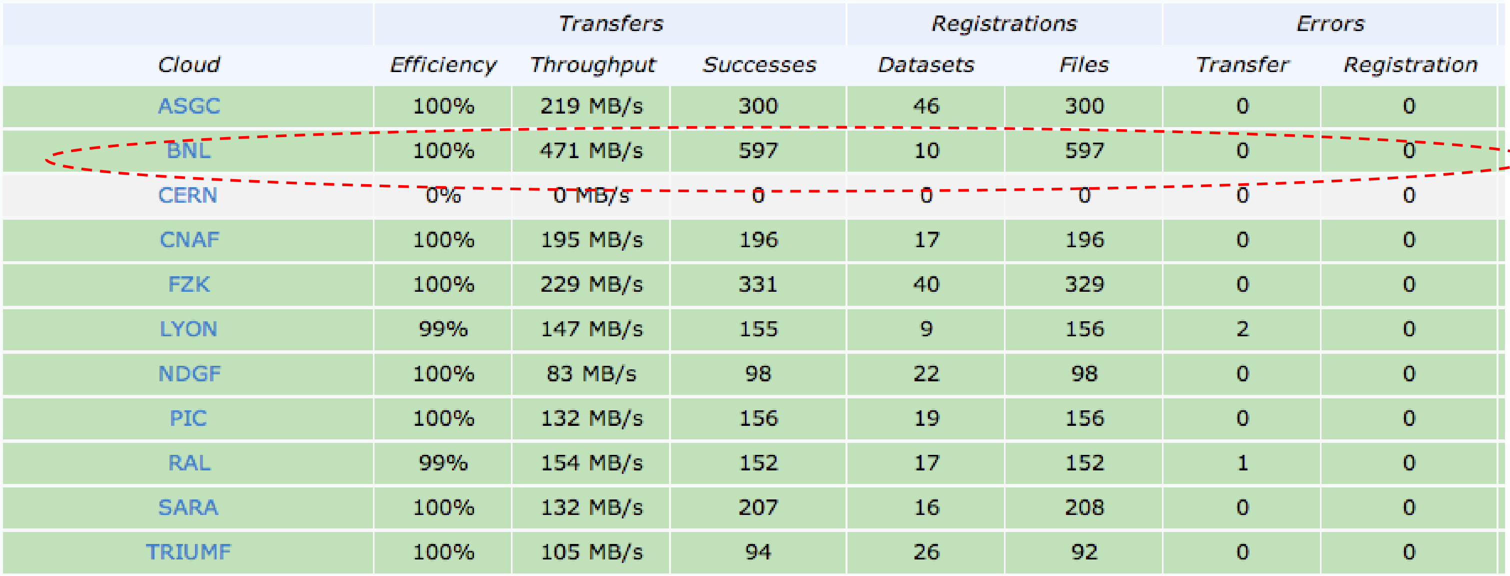
CCRC08

- Combined Computing Readiness Challenge of 2008
  - LHC-wide computing challenge,
    - a preparatory Phase 1 series of tests conducted in February,
    - main Phase 2 conducted in May, 2008.
  - ATLAS in CCRC08
    - Tests carried along for the all month
      - **CCRC08 ONLY during week days**
      - Cosmic data during the weekend (commissioning and M7)
    - Focused on data distribution according to Computing Model
    - Tier0->Tier1's, Tier1->Tier1's, Tier1->Tier2's
    - Very demanding metrics
      - More than you will need to do during 2008 data taking

CCRC08 (Tier0-Tier1’s)

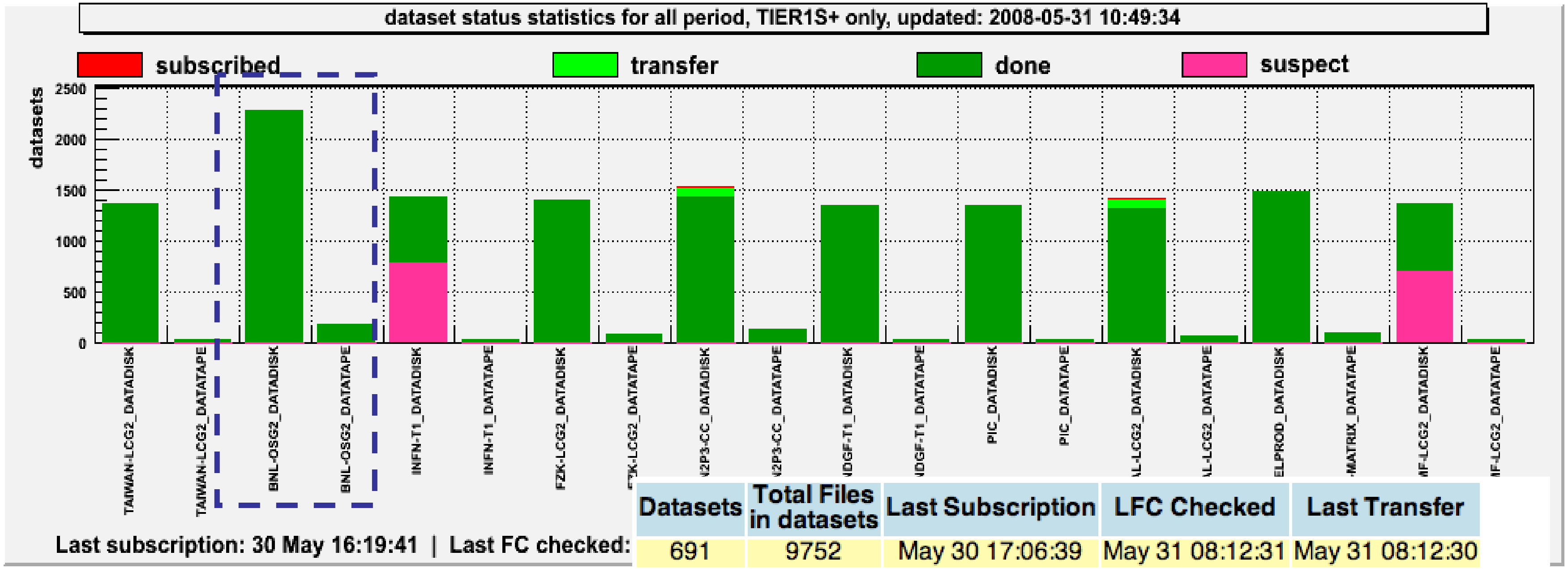
- T0->T1: sites should demonstrate to be capable to import 100% of the subscribed datasets (complete datasets) within 6 hours from the end of the exercise





	Transfers			Registrations		Errors	
Cloud	Efficiency	Throughput	Successes	Datasets	Files	Transfer	Registration
ASGC	100%	219 MB/s	300	46	300	0	0
BNL	100%	471 MB/s	597	10	597	0	0
CERN	0%	0 MB/s	0	0	0	0	0
CNAF	100%	195 MB/s	196	17	196	0	0
FZK	100%	229 MB/s	331	40	329	0	0
LYON	99%	147 MB/s	155	9	156	2	0
NDGF	100%	83 MB/s	98	22	98	0	0
PIC	100%	132 MB/s	156	19	156	0	0
RAL	99%	154 MB/s	152	17	152	1	0
SARA	100%	132 MB/s	207	16	208	0	0
TRIUMF	100%	105 MB/s	94	26	92	0	0

CCRC08 (Tier0-Tier1's)

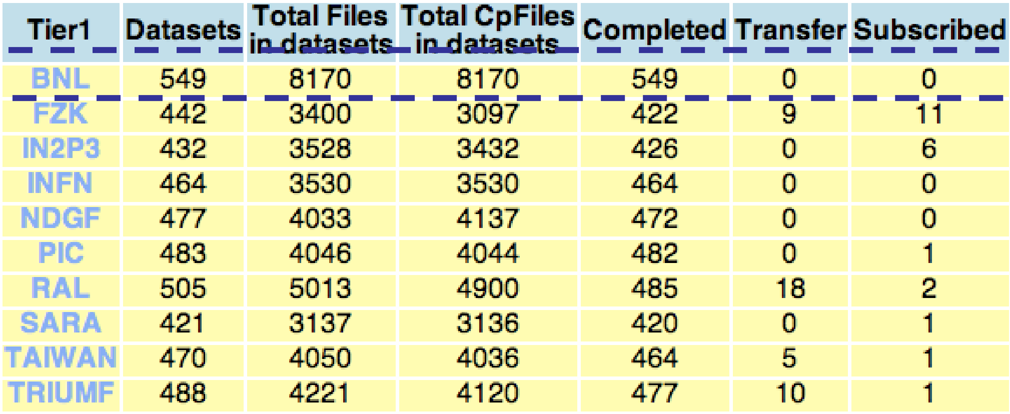


Datasets	Total Files in datasets	Last Subscription	LFC Checked	Last Transfer
691	9752	May 30 17:06:39	May 31 08:12:31	May 31 08:12:30

BNL managed to get all data with average throughput 470+MB/s (1.55 times more than nominal)

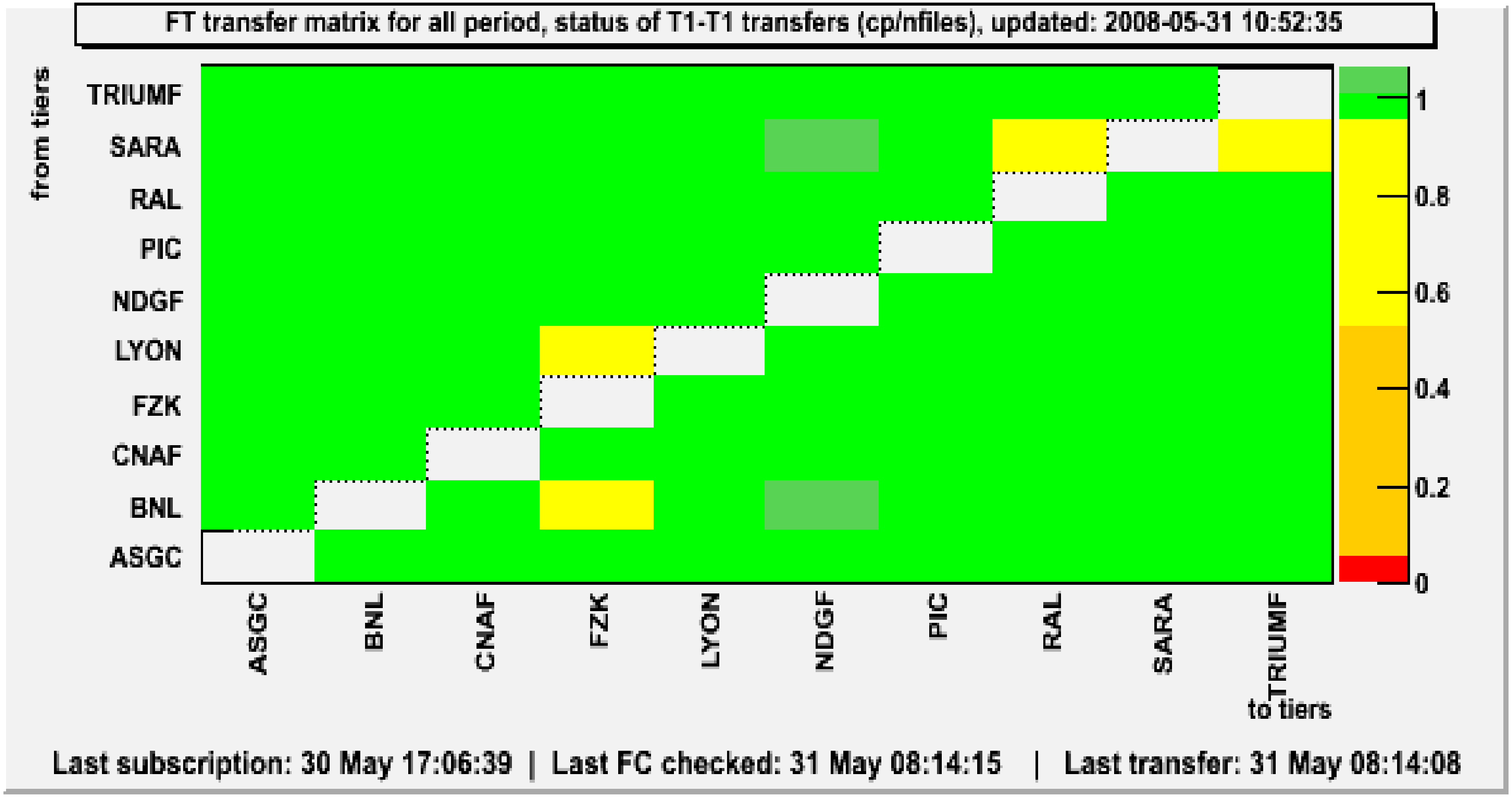
All transfers to BNL instances (DISK and TAPE) were completed

Backlog was recovered within 24h (after CERN power cut)



Tier1	Datasets	Total Files in datasets	Total CpFiles in datasets	Completed	Transfer	Subscribed
BNL	549	8170	8170	549	0	0
FZK	442	3400	3097	422	9	11
IN2P3	432	3528	3432	426	0	6
INFN	464	3530	3530	464	0	0
NDGF	477	4033	4137	472	0	0
PIC	483	4046	4044	482	0	1
RAL	505	5013	4900	485	18	2
SARA	421	3137	3136	420	0	1
TAIWAN	470	4050	4036	464	5	1
TRIUMF	488	4221	4120	477	10	1

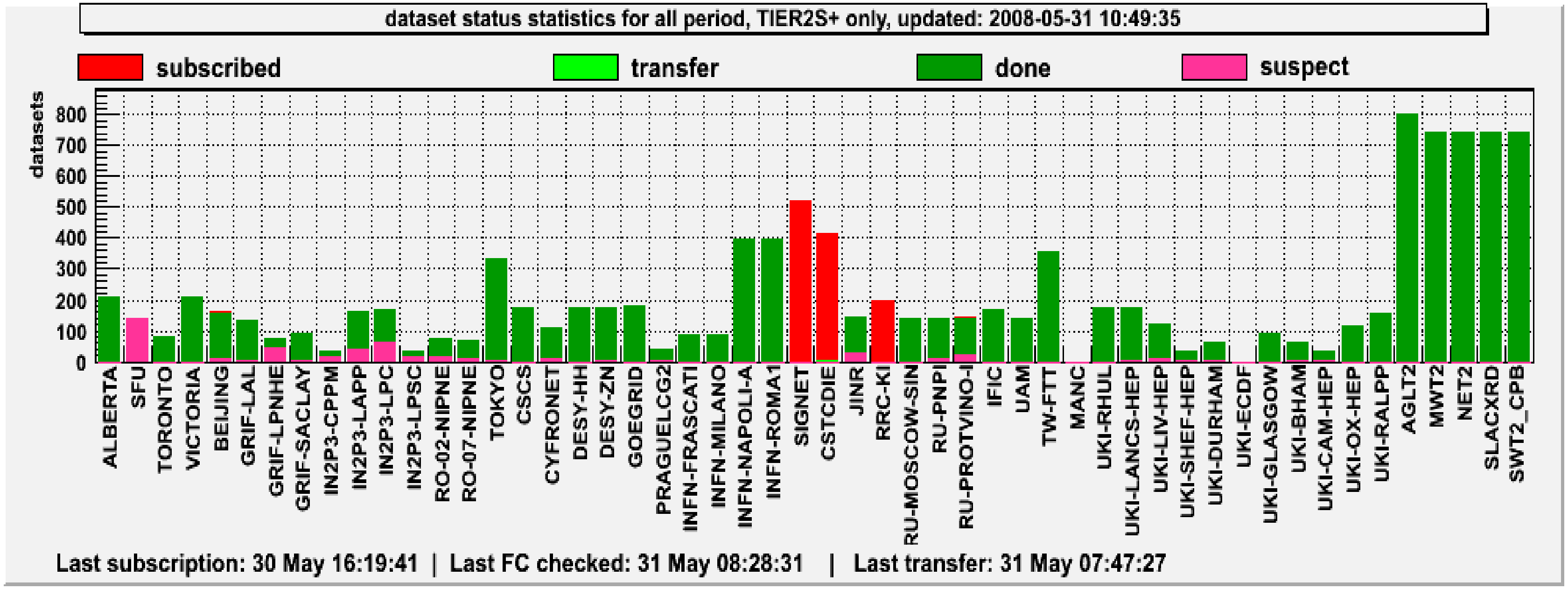
CCRC08 : Tier1-Tier1’s

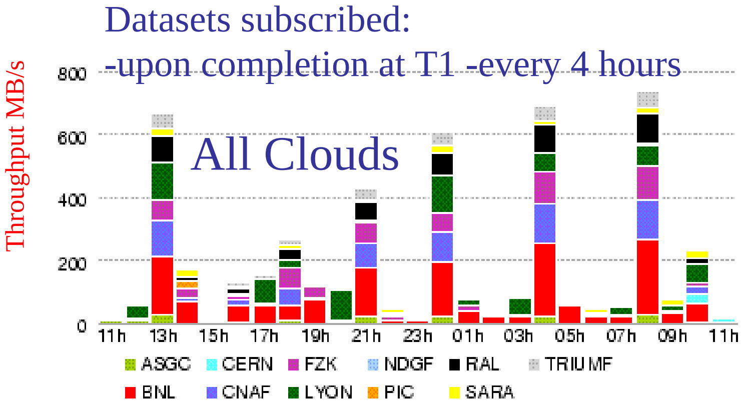


FT transfer matrix for all period, status of T1-T1 transfers (cp/nfiles), updated: 2008-05-31 10:52:35

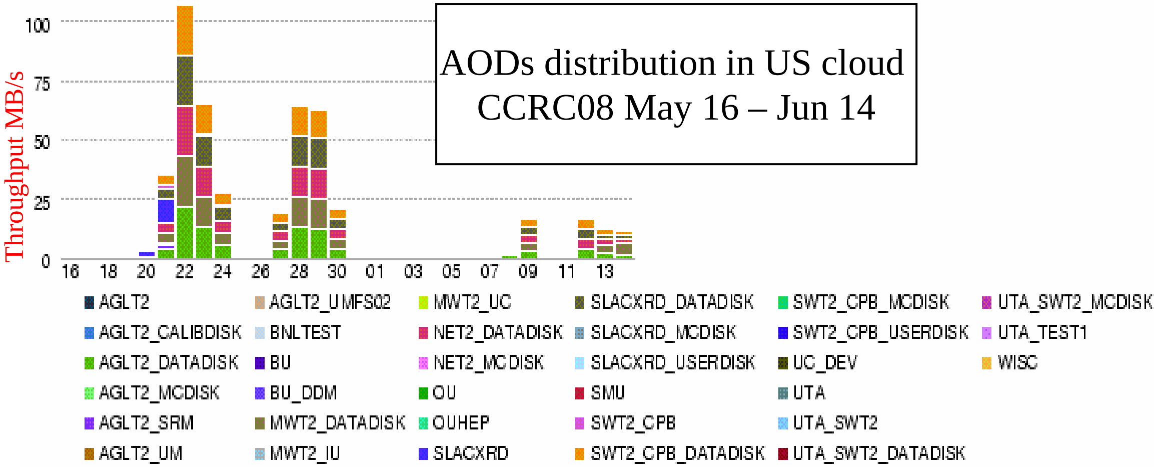
Last subscription: 30 May 17:06:39 | Last FC checked: 31 May 08:14:15 | Last transfer: 31 May 08:14:08

CCRC08 : Tier1-Tier2’s




Datasets subscribed:
-upon completion at T1 -every 4 hours

All Clouds


AODs distribution in US cloud
CCRC08 May 16 – Jun 14

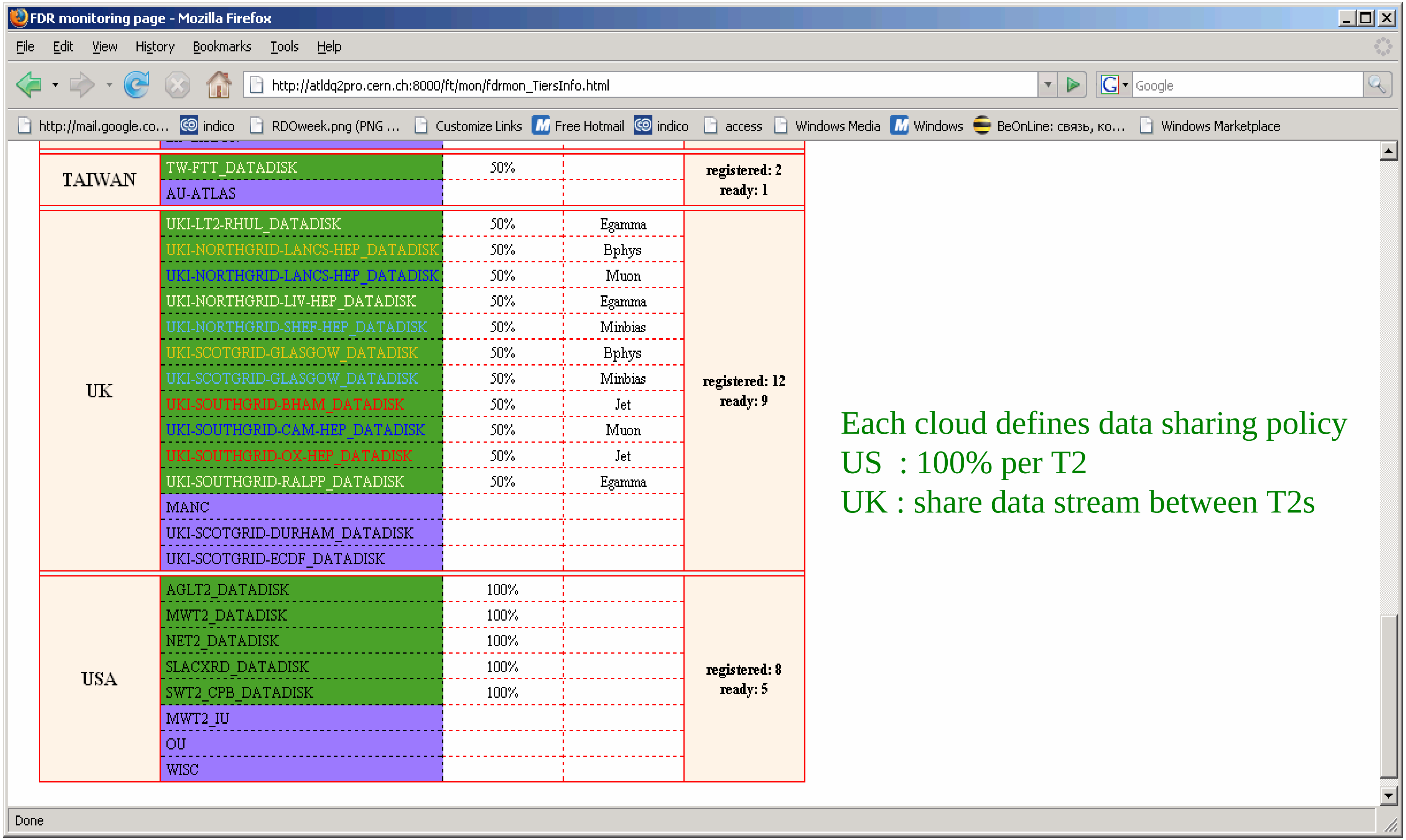
Full Dress Rehearsal – II (FDR-II)

ATLAS tried to practice everything — from data coming off the experiment right through to it being shipped around and analyzed — under conditions just as they will be when real data–taking begins.

Test scope :

- Simulated data in RAW data format are pre-loaded on the output buffers of the online computing farm and transmitted to the Tier-0 farm at nominal rate (200 Hz, 320 MB/s), mimicking the LHC operation cycle
- Data are calibrated/aligned/reconstructed at Tier-0 and distributed to Tier-1 and Tier-2 centres, following the computing model
- At the same time, distributed simulation production and distributed analysis activities continue, providing a constant background load
- Reprocessing at Tier-1s is also tested in earnest for the first time

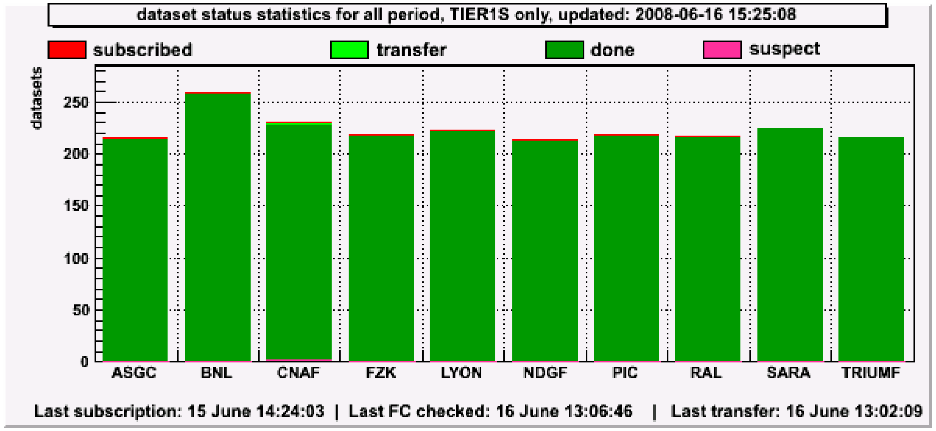
FDR-II. Data sharing within clouds



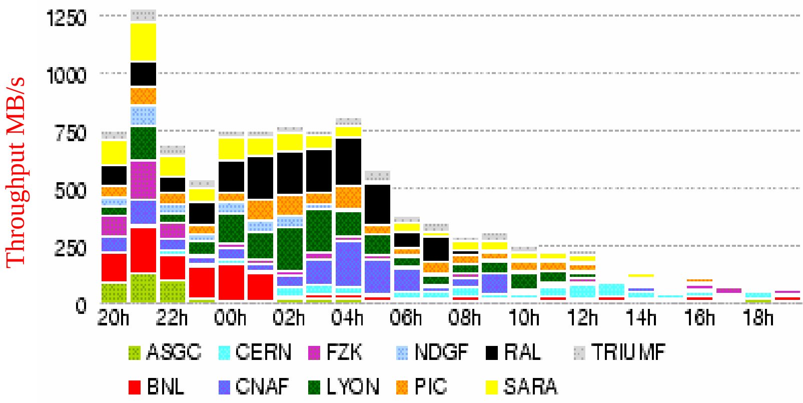
TAIWAN	TW-FTT_DATADISK	50%		registered: 2 ready: 1
	AU-ATLAS			
UK	UKI-LT2-RHUL_DATADISK	50%	Egamma	registered: 12 ready: 9
	UKI-NORTHGRID-LANCS-HEP_DATADISK	50%	Bphys	
	UKI-NORTHGRID-LANCS-HEP_DATADISK	50%	Muon	
	UKI-NORTHGRID-LIV-HEP_DATADISK	50%	Egamma	
	UKI-NORTHGRID-SHEF-HEP_DATADISK	50%	Minbias	
	UKI-SCOTGRID-GLASGOW_DATADISK	50%	Bphys	
	UKI-SCOTGRID-GLASGOW_DATADISK	50%	Minbias	
	UKI-SOUTHGRID-BHAM_DATADISK	50%	Jet	
	UKI-SOUTHGRID-CAM-HEP_DATADISK	50%	Muon	
	UKI-SOUTHGRID-OX-HEP_DATADISK	50%	Jet	
	UKI-SOUTHGRID-RALPP_DATADISK	50%	Egamma	
	MANC			
	UKI-SCOTGRID-DURHAM_DATADISK			
	UKI-SCOTGRID-ECDF_DATADISK			
USA	AGLT2_DATADISK	100%		registered: 8 ready: 5
	MWT2_DATADISK	100%		
	NET2_DATADISK	100%		
	SLACXRD_DATADISK	100%		
	SWT2_CPB_DATADISK	100%		
	MWT2_IU			
	OU			
	WISC			

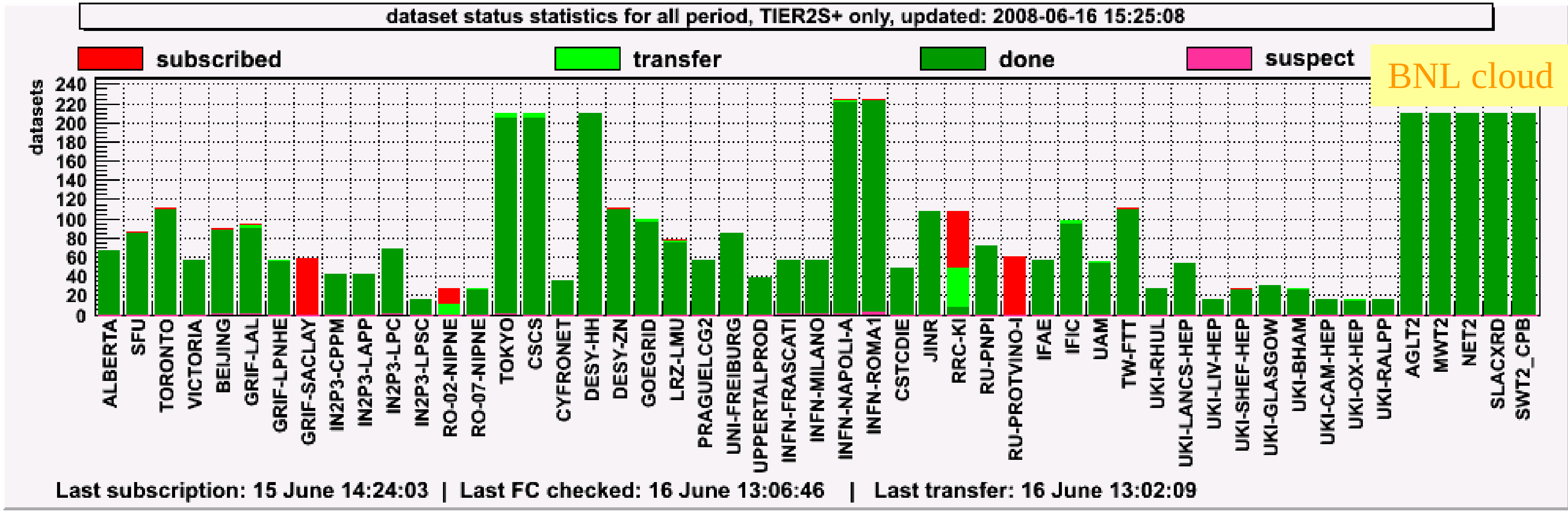
Each cloud defines data sharing policy
US : 100% per T2
UK : share data stream between T2s

FDR-II (data replication)


dataset status statistics for all period, TIER1S only, updated: 2008-06-16 15:25:08

Last subscription: 15 June 14:24:03 | Last FC checked: 16 June 13:06:46 | Last transfer: 16 June 13:02:09




dataset status statistics for all period, TIER2S+ only, updated: 2008-06-16 15:25:08

BNL cloud

Last subscription: 15 June 14:24:03 | Last FC checked: 16 June 13:06:46 | Last transfer: 16 June 13:02:09

FDR-II DDM issues (summary)

- From ATLAS Physics Coordination
  - Data transport - OK
    - DDM generally worked well - both in shipping files to CERN and shipping them out after FDR running Shipped 18h of FDR-2 RAW data out within <24h, successfully to all Tier-1s and Tier-2s
- From ATLAS Distributed Computing (FDR-II+CCRC08)
  - Known problems :
    - Double files registration
      - The problem never happened in US cloud
        - » Working idea of DQ2 developers that it is in between DQ2 and LFC SW
      - Description
        - » The file is transferred correctly to site and registered in LFC
        - » "Something" goes wrong and the file is replicated again
        - » Another entry in LFC, same GUID, different SURL
    - Delay up to 4h with central catalog update (site replicas info)
      - The problem is understood and fixed
    - Delay up to 2h with start of data replication

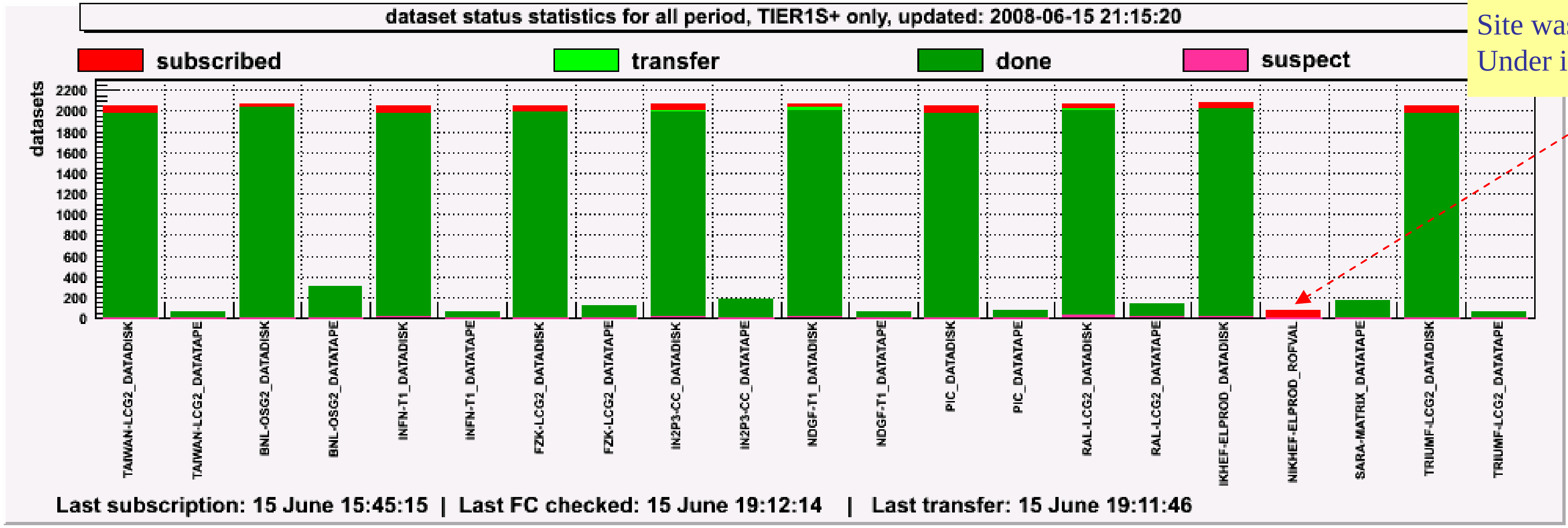
Functional and Throughput Tests

- Starting from 2007 ATLAS Operations runs FT and TT

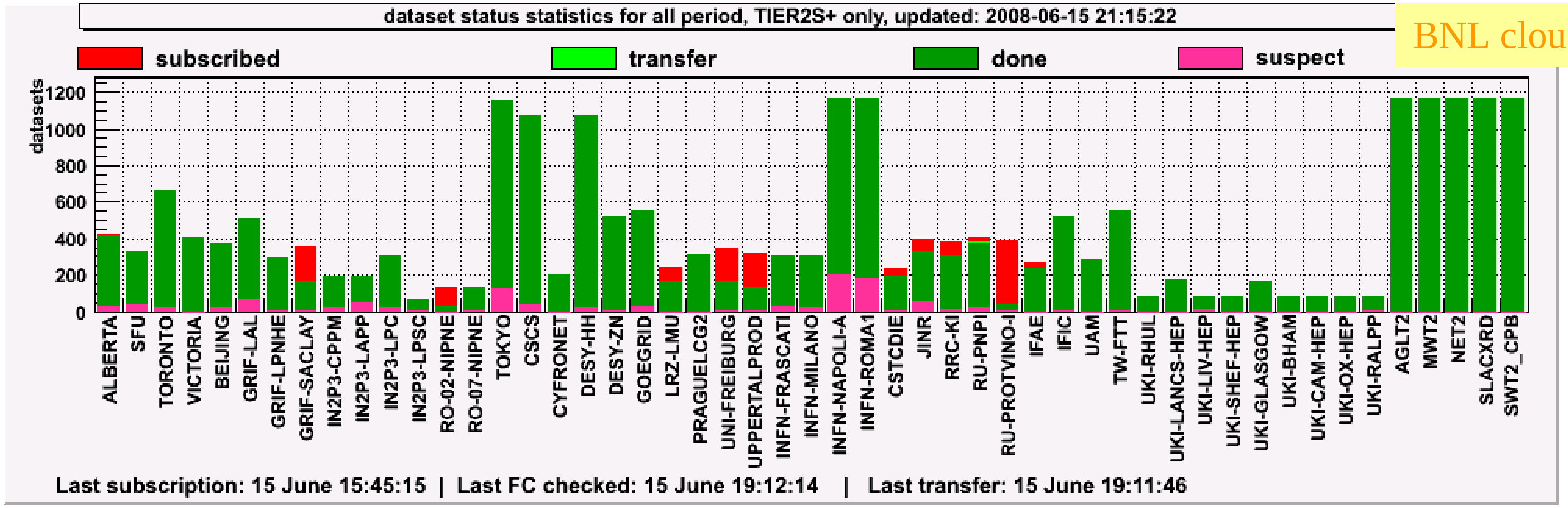
  FT was proposed by P.Nevski and A.Klimentov to test system functionality and performance

  - Initially 5 times per year after major SW releases
  - From Jun 2008 : continuously to exercise data transfer
- Test scope
  - » Run data generator at 10% of nominal rate:
  - » Distribute RAW, ESD, AOD according to Computing Model
  - » Tier-0 – Tier-1’s data transfer
  - » Tier-1-Tier-1’s data transfer
  - » Tier-1-Tier-2’s data transfer
  - » Subscribe ‘calibration’ datasets from CERN to 5 Tier-2s + CNAF and BNL
  - » 10 Tier-1s and 60 Tier-2s are participating
  - » Statistics is generated automatically
  - » Exercise Operations shifts

Functional Tests (cont)

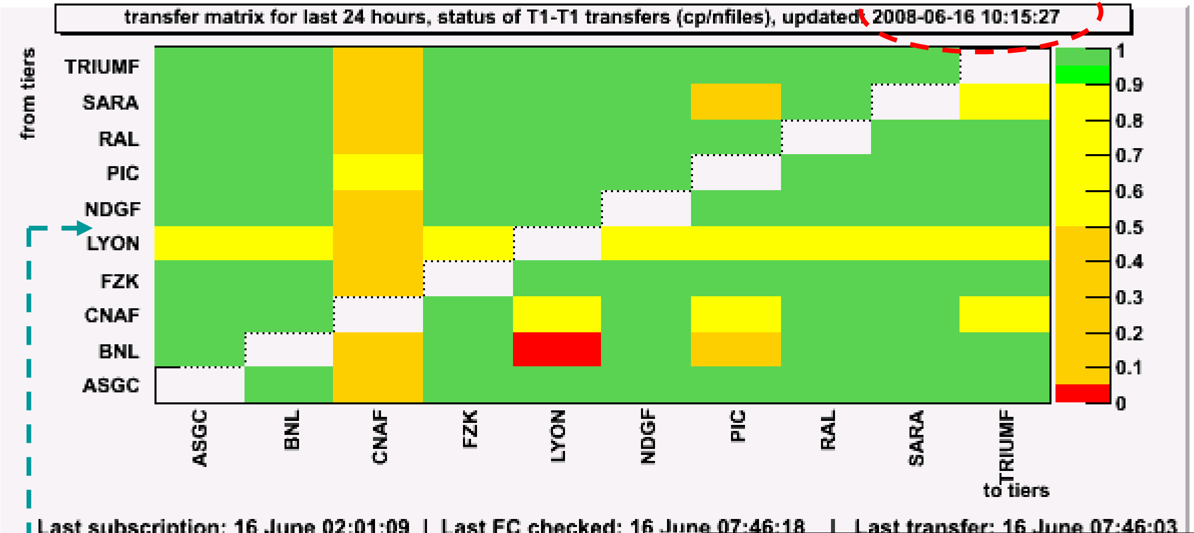


Site was set up Jun 14th
Under investigation

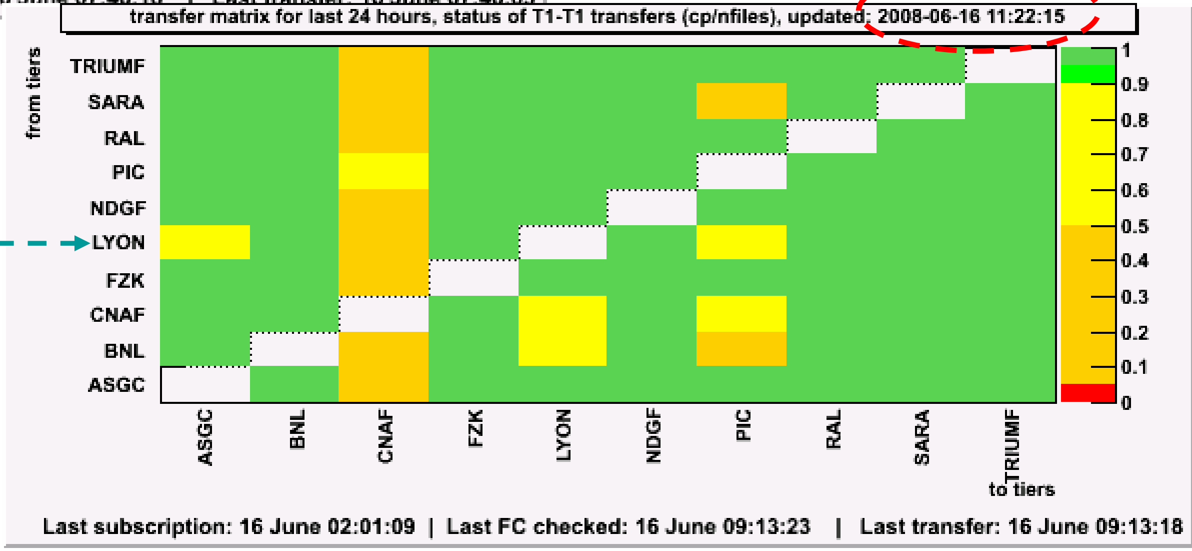


BNL cloud

Functional Test ("current" status)



FT data replication status for the last 24h
LYON and CNAF experienced problems
Data replication performance between other Tier-1s is close to 100%



and 1h later LYON recovered backlog
Problem with INFN persists

Conclusions

- **The data distribution scenario has been tested well beyond the use case for 2008 data taking**

- **US ATLAS Computing and Networking infrastructure met the experiment’s requirements.**

- **ATLAS DDM Software is stable and met data replication requirements**

Acknowledgements

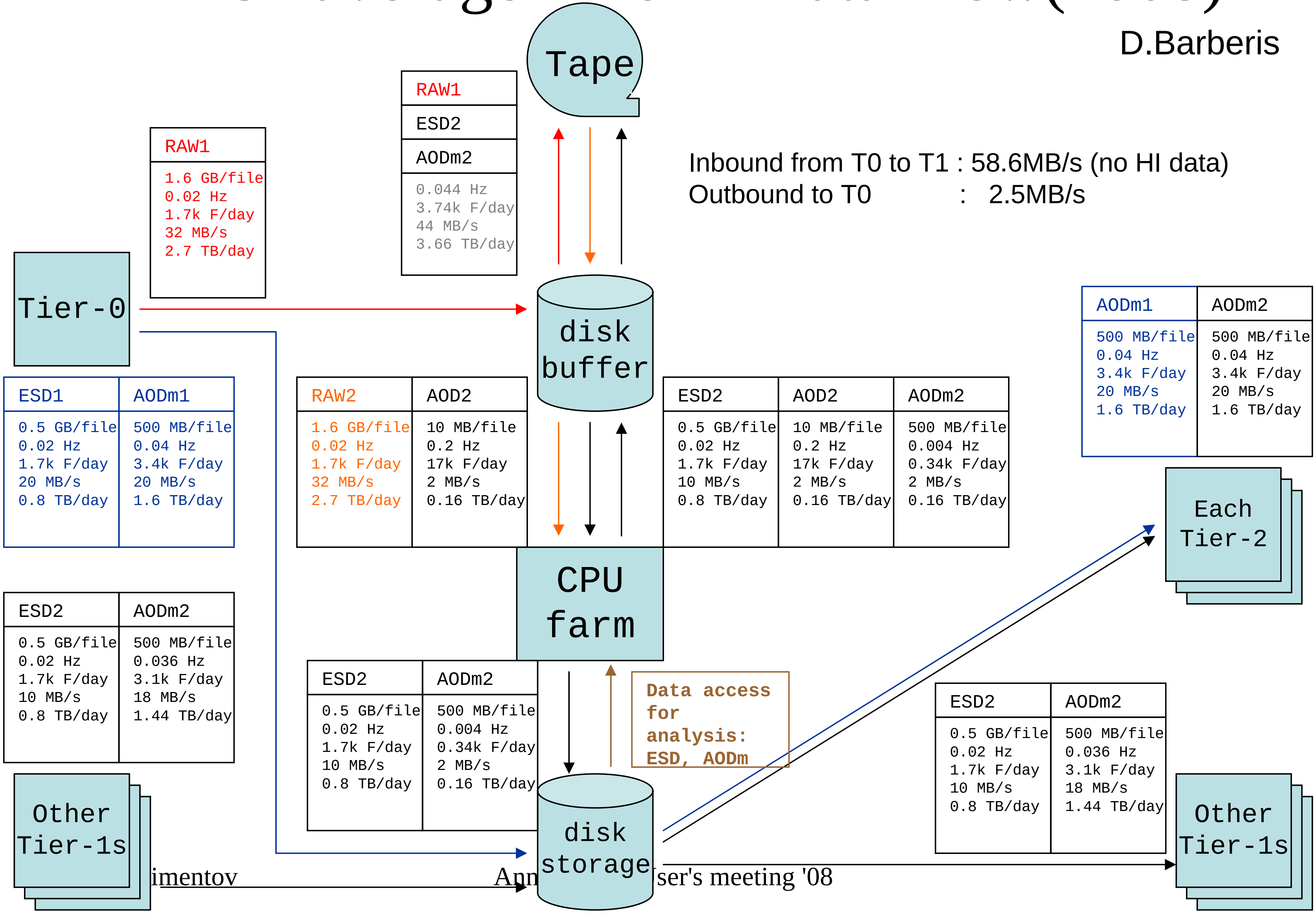
- Thanks to my colleagues A.Anisenkov, D.Barberis, M.Branco, S.Campana, A.Farbin and A.Vanyashine for slides and courtesy pictures used in this presentation.

BACKUP SLIDES

ATLAS “average” Tier-1 Data Flow(2008)

D.Barberis

Inbound from T0 to T1 : 58.6MB/s (no HI data)
Outbound to T0 : 2.5MB/s



RAW1
1.6 GB/file 0.02 Hz 1.7k F/day 32 MB/s 2.7 TB/day

RAW1
ESD2
AODm2
0.044 Hz 3.74k F/day 44 MB/s 3.66 TB/day

ESD1	AODm1
0.5 GB/file 0.02 Hz 1.7k F/day 20 MB/s 0.8 TB/day	500 MB/file 0.04 Hz 3.4k F/day 20 MB/s 1.6 TB/day

RAW2	AOD2
1.6 GB/file 0.02 Hz 1.7k F/day 32 MB/s 2.7 TB/day	10 MB/file 0.2 Hz 17k F/day 2 MB/s 0.16 TB/day

ESD2	AOD2	AODm2
0.5 GB/file 0.02 Hz 1.7k F/day 10 MB/s 0.8 TB/day	10 MB/file 0.2 Hz 17k F/day 2 MB/s 0.16 TB/day	500 MB/file 0.004 Hz 0.34k F/day 2 MB/s 0.16 TB/day

AODm1	AODm2
500 MB/file 0.04 Hz 3.4k F/day 20 MB/s 1.6 TB/day	500 MB/file 0.04 Hz 3.4k F/day 20 MB/s 1.6 TB/day

ESD2	AODm2
0.5 GB/file 0.02 Hz 1.7k F/day 10 MB/s 0.8 TB/day	500 MB/file 0.036 Hz 3.1k F/day 18 MB/s 1.44 TB/day

ESD2	AODm2
0.5 GB/file 0.02 Hz 1.7k F/day 10 MB/s 0.8 TB/day	500 MB/file 0.004 Hz 0.34k F/day 2 MB/s 0.16 TB/day

Data access for analysis: ESD, AODm

ESD2	AODm2
0.5 GB/file 0.02 Hz 1.7k F/day 10 MB/s 0.8 TB/day	500 MB/file 0.036 Hz 3.1k F/day 18 MB/s 1.44 TB/day

DQ2 Concepts

- ‘Dataset’:
  - an aggregation of data (spanning more than one physical file!), which are processed together and serve collectively as input or output of a computation or data acquisition process.
  - Flexible definition:
    - … can be used for grouping related data (e.g. RAW from a run with a given luminosity)
    - … can be used for data movement purposes
  - Dataset concept is extended to all ATLAS data (MC, DAQ, DB releases, etc)
- ‘File’:
  - constituent of a dataset
    - Identified by Logical File Name (LFN) and GUID
- ‘Site’
  - A computing site providing storage facilities for ATLAS
    - … which may be a federated site
- ‘Subscription’
  - Mechanism to request updates of a dataset to be delivered to a site

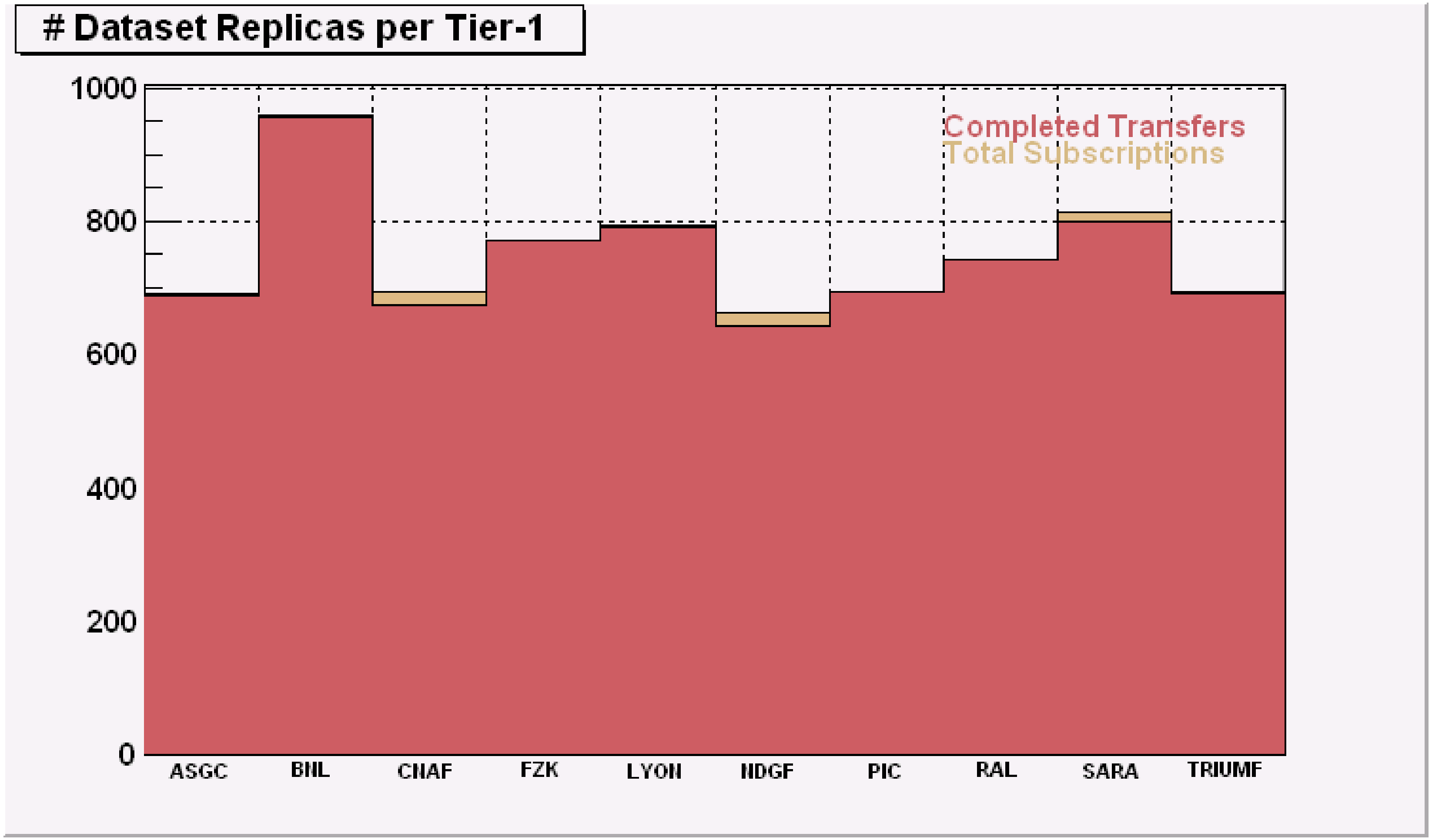
See M.Lassnig talk CHEP Sep 3, GM2 session

DDM/DQ2 more than just s/w development

- DDM forced the introduction of many concepts, defined in the Computing Model, onto the middleware:
  - ATLAS Association between Tier-1/Tier-2s
  - Distinction between temporary (e.g. disk) and archival (e.g. tape) areas
  - Datasets as the unit of data handling
- Not all ATLAS concepts were originally supported by the GRID middleware.

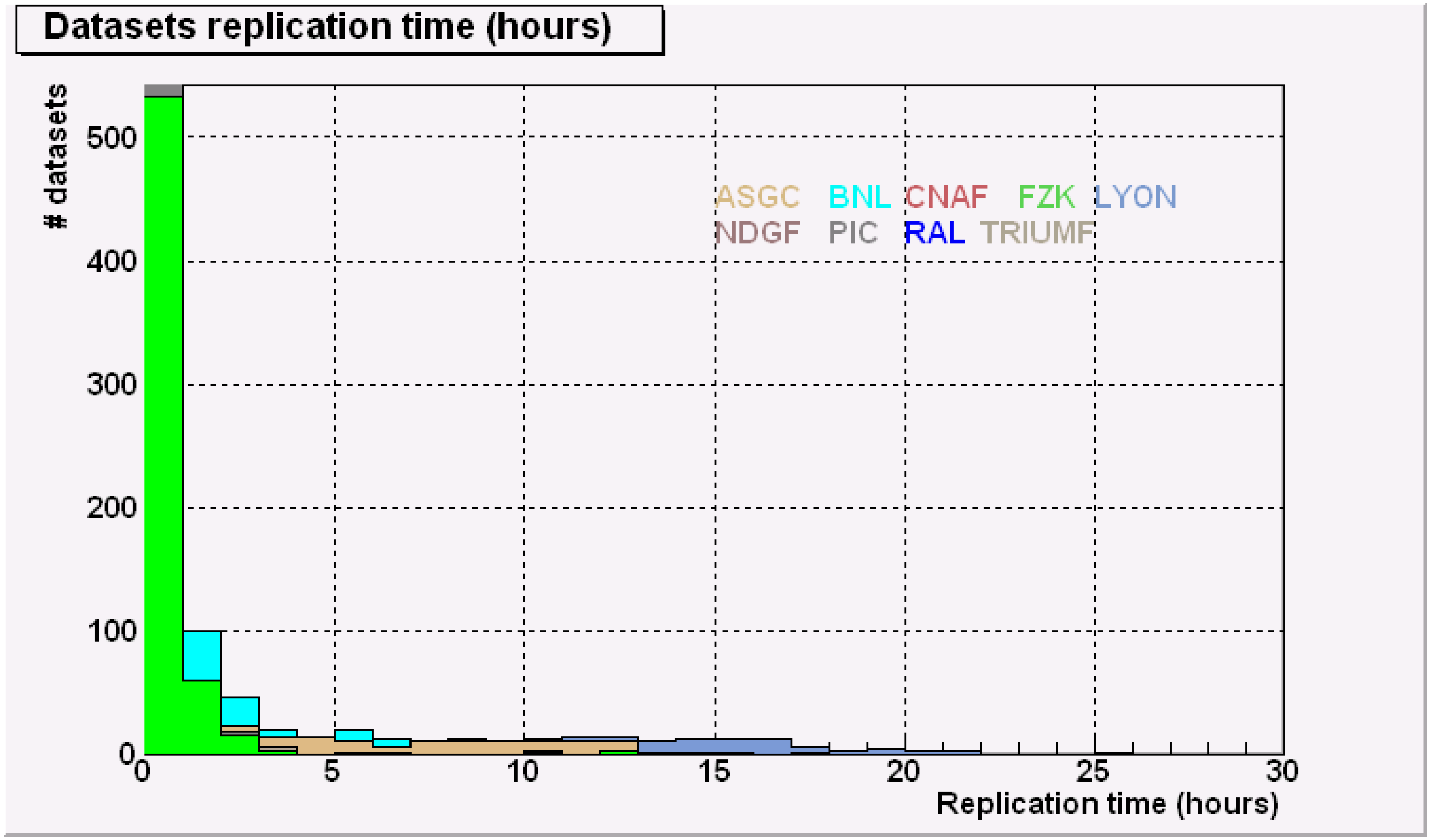
See M.Lassnig talk CHEP Sep 3, GM2 session

CCRC08. May 2008 (week 19)



A.Klimentov,K.Leffhalm Jun 10, 2008

CCRC08 May 2008 (week 19). Replication Processing



A.Klimentov,K.Leffhalm Jun 10, 2008

DDM Glossary

- ‘Dataset’:
  - an aggregation of data (spanning more than one physical file!), which are processed together and serve collectively as input or output of a computation or data acquisition process.
  - Flexible definition:
    - … can be used for grouping related data (e.g. RAW from a run with a given luminosity)
    - … can be used for data movement purposes
  - Dataset concept is extended to all ATLAS data (MC, DAQ, DB releases, etc)

Duality and many potential and existing problems are coming form it

- *Dataset is a unit of replication*
- *Dataset is a unit of physics data organization*

- ‘File’:
  - constituent of a dataset
    - Identified by Logical File Name (LFN) and GUID
- ‘Site’
  - A computing site providing storage facilities for ATLAS
    - … which may be a federated site
- ‘Subscription’
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