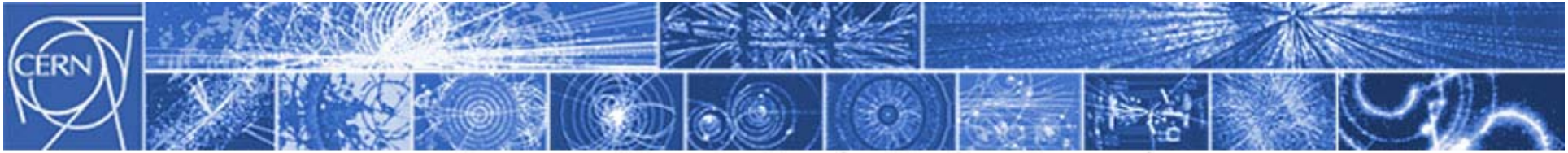


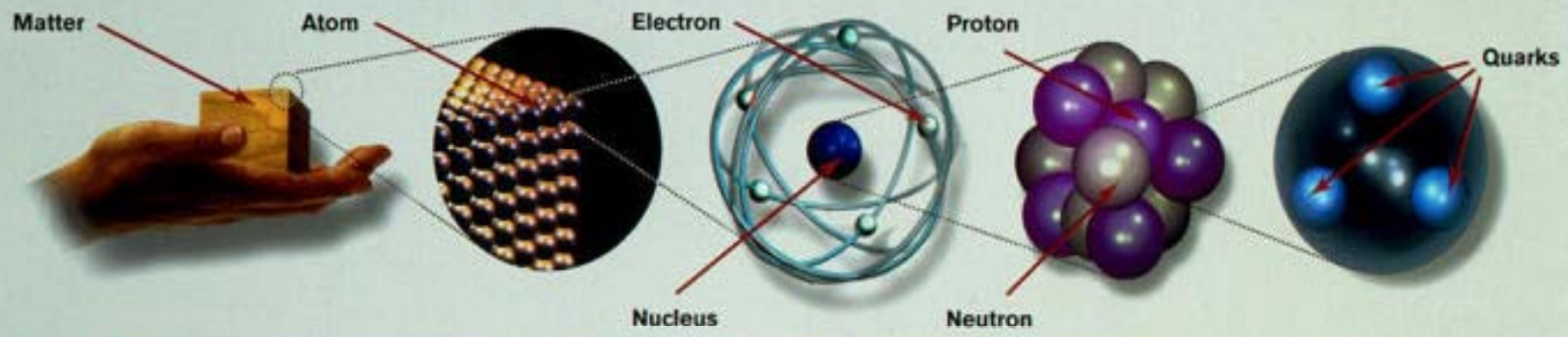
CERN

European Organization for Nuclear Research
Organisation Européenne pour la Recherche Nucléaire

Data and Database Challenges at CERN

Tony Cass
Leader, Database Services Group
Information Technology Department

29th May 2010



Matter particles

All ordinary particles belong to this group

These particles existed just after the Big Bang. Now they are found only in cosmic rays and accelerators

LEPTONS

FIRST FAMILY	**Electron** Responsible for electricity and chemical reactions; it has a charge of -1	**Electron neutrino** Particle with no electric charge, and possibly no mass; billions fly through your body every second
SECOND FAMILY	**Muon** A heavier relative of the electron; it lives for two-millionths of a second	**Muon neutrino** Created along with muons when some particles decay
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These particles transmit the four fundamental forces of nature although gravitons have so far not been discovered

Gluons
Carriers of the strong force between quarks

Felt by: quarks

The explosive release of nuclear energy is the result of the strong force

Photons
Particles that make up light; they carry the electromagnetic force

Felt by: quarks and charged leptons

Electricity, magnetism and chemistry are all the results of electro-magnetic force

Intermediate vector bosons
Carriers of the weak force

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Some forms of radio-activity are the result of the weak force

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Carriers of gravity

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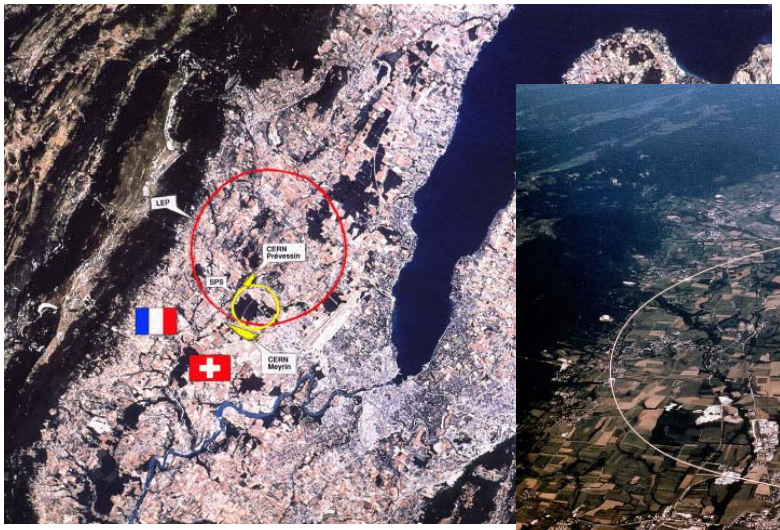
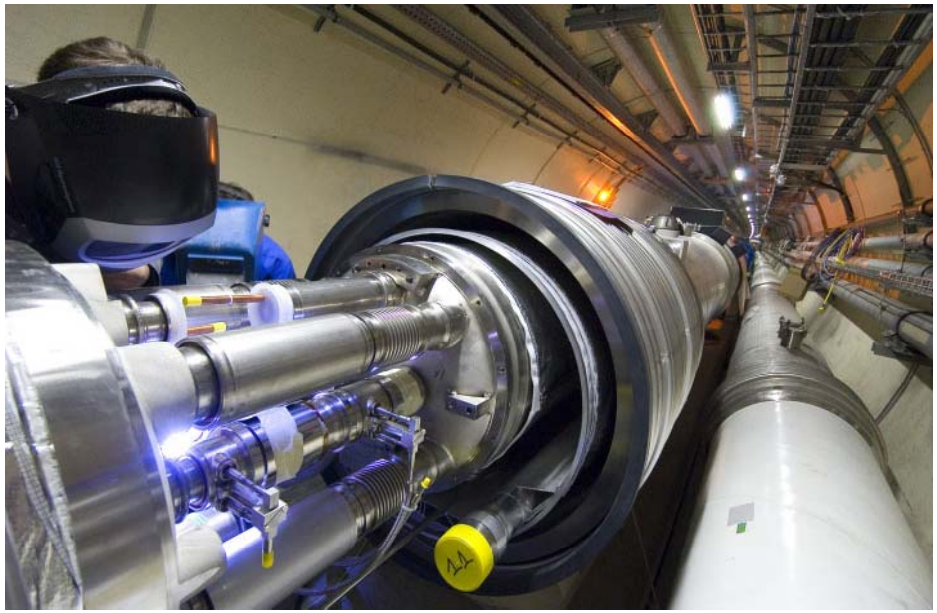
CERN

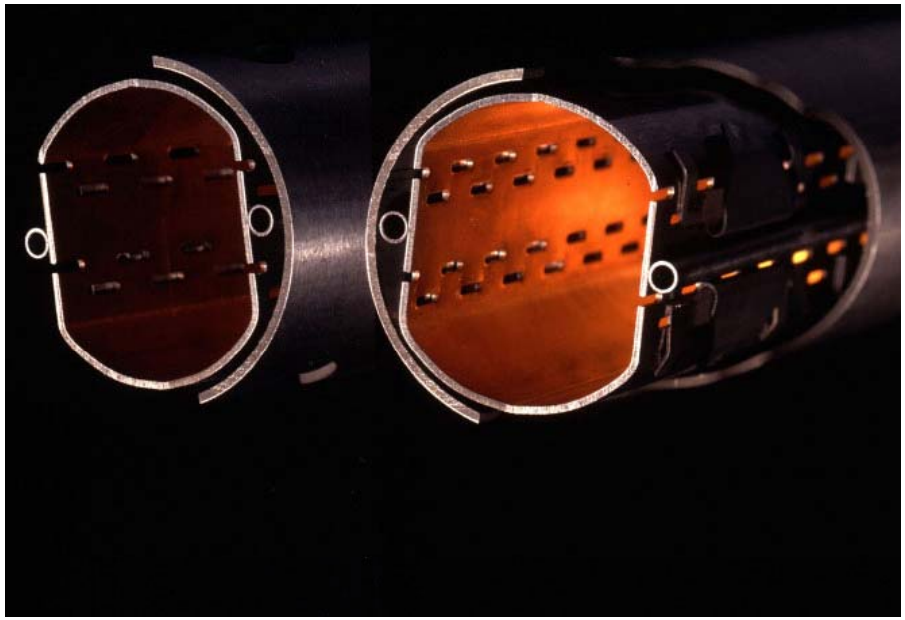
The fastest racetrack on the planet…



Trillions of protons will race around the 27km ring in opposite directions over 11,000 times a second, travelling at 99.999999991 per cent the speed of light.

The emptiest space in the solar system…





To accelerate protons to almost the speed of light requires a vacuum as empty as interplanetary space. There is 10 times more atmosphere on the moon than there will be in the LHC.

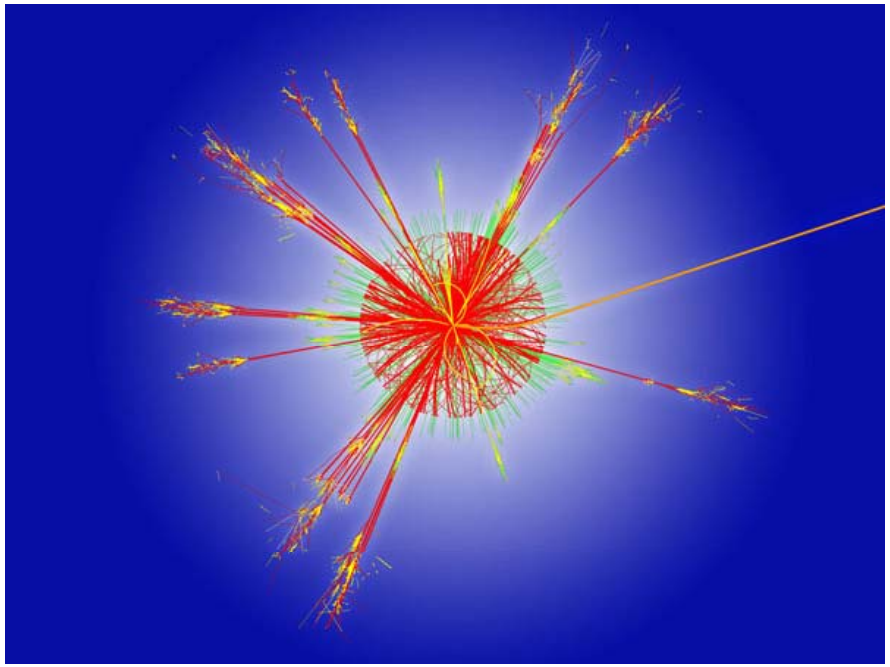
CERN

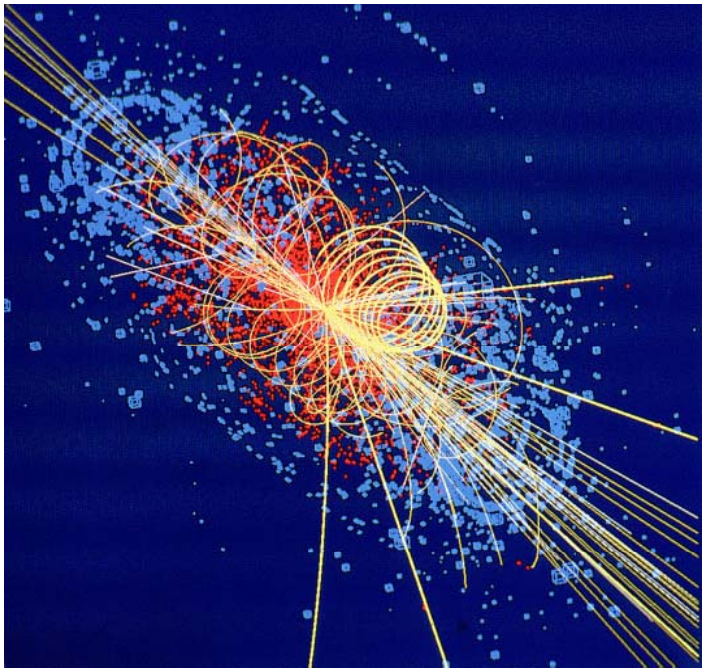
One of the coldest places in the universe…

With an operating temperature of about -271 degrees Celsius, just 1.9 degrees above absolute zero, the LHC is colder than outer space.

CERN

The hottest spots in the galaxy…

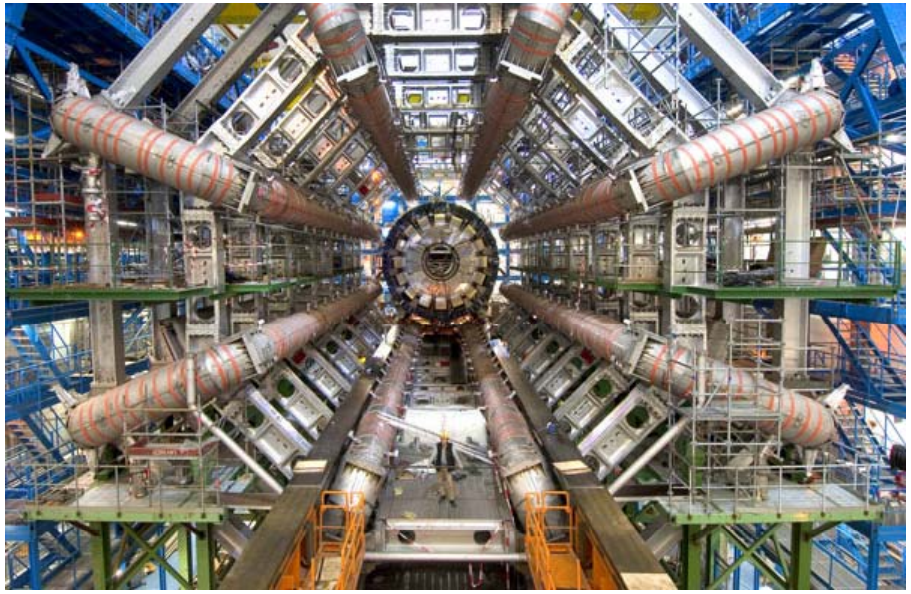




When two beams of protons collide, they will generate temperatures 1000 million times hotter than the heart of the sun, but in a minuscule space.

CERN

The biggest most sophisticated detectors ever built…



To sample and record the debris from up to 600 million proton collisions per second, scientists are building gargantuan devices that measure particles with micron precision.

CERN

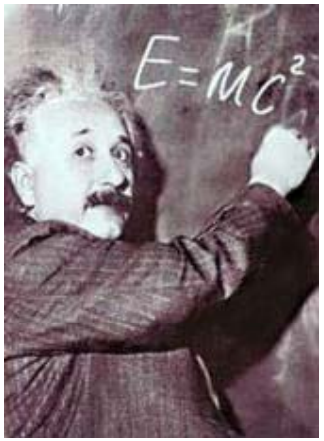
The most extensive computer system in the world…

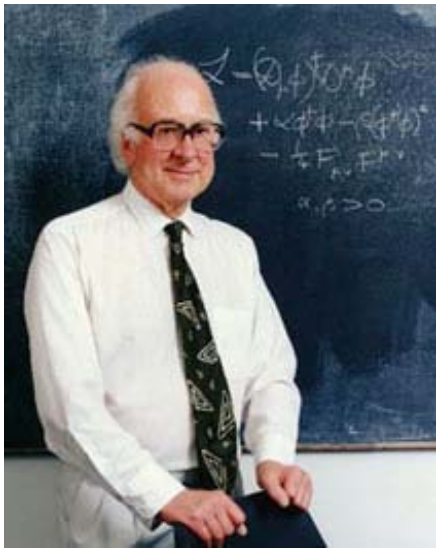
To analyse the data, tens of thousands of computers around the world are being harnessed in the Grid. The laboratory that gave the world the web, is now taking distributed computing a big step further.

Why?

CERN

To push back the frontiers of knowledge…



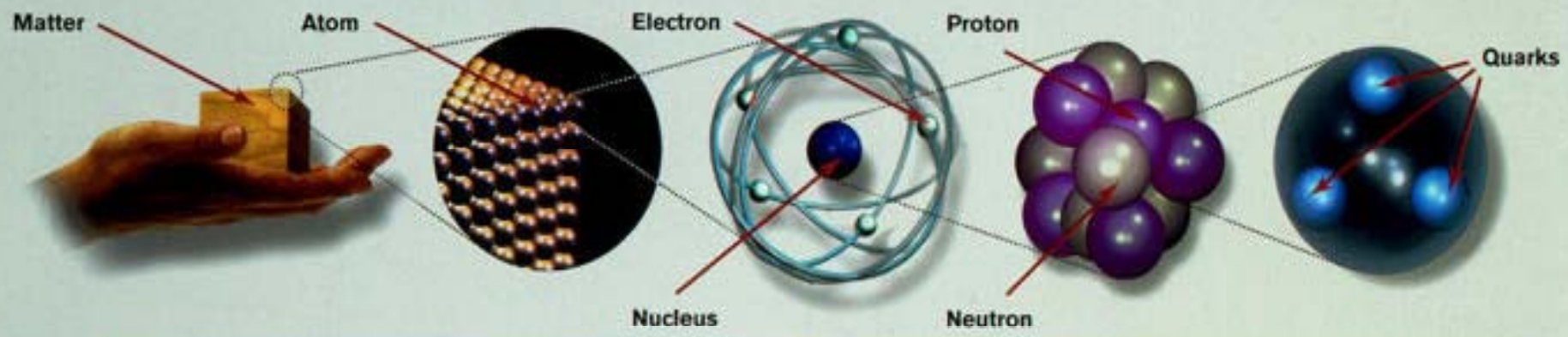


Newton's unfinished business… what is mass?

Science's little embarrassment… what is 96% of the Universe made of?

Nature's favouritism… why is there no more antimatter?

The secrets of the Big Bang… what was matter like within the first second of the Universe's life?



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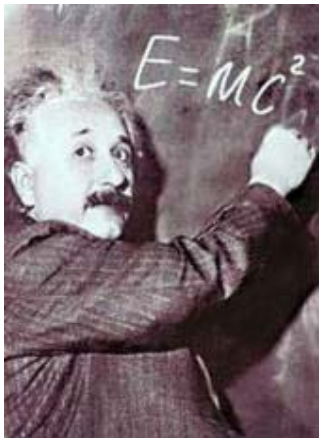

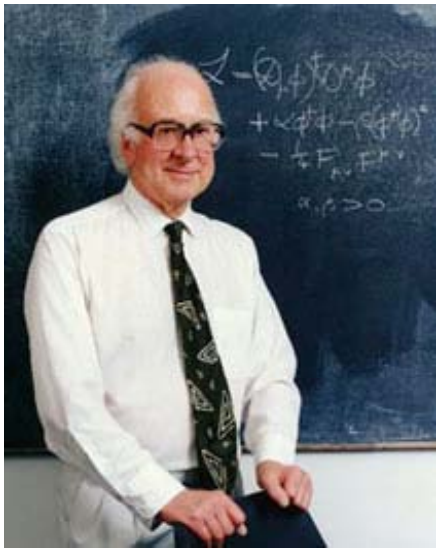

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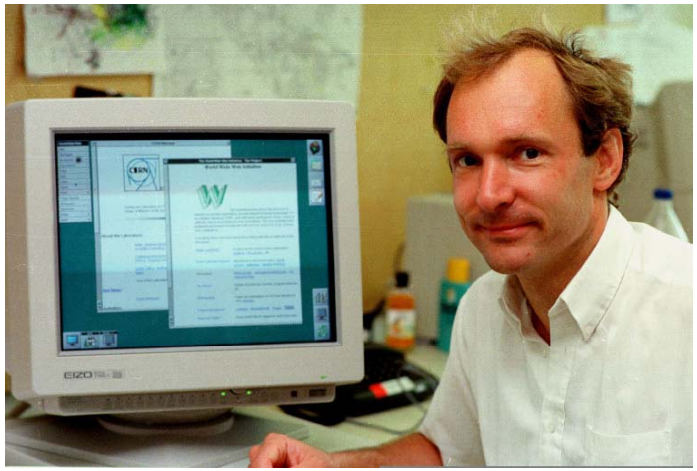
To develop new technologies…



Information technology - the Web and the Grid

Medicine - diagnosis and therapy

Security - scanning technologies for harbours and airports

Vacuum - new techniques for flat screen displays or solar energy devices

CERN

To unite people from different countries and cultures…

20 Member states

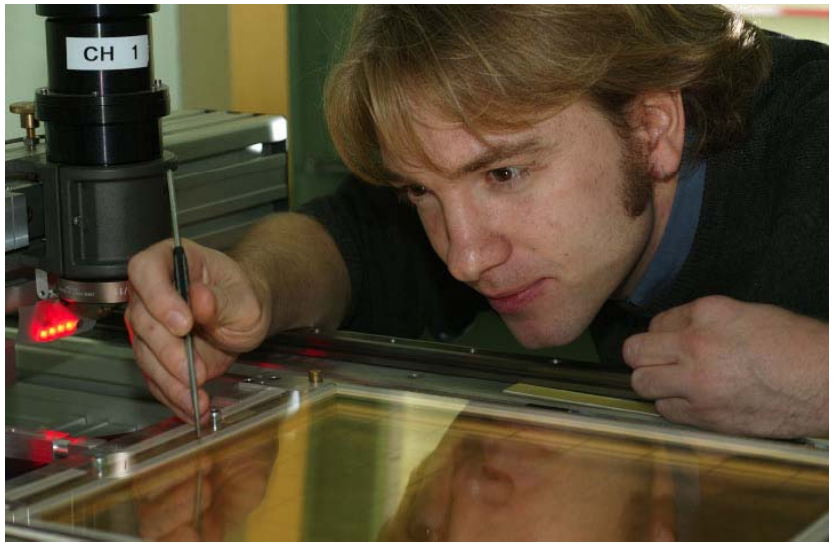
38 Countries with cooperation agreements

111 Nationalities

10000 People

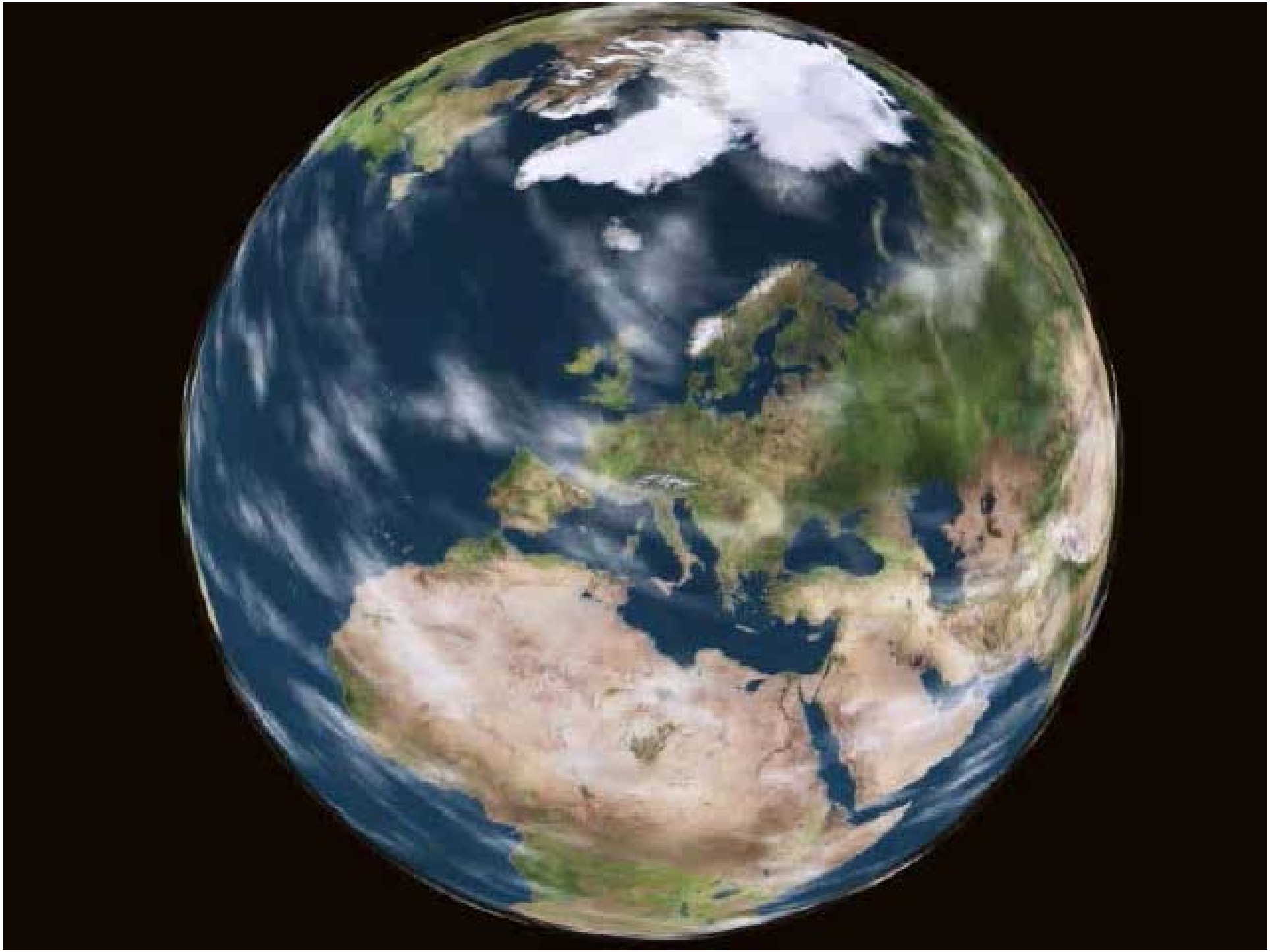
CERN

To train the scientists and engineers of tomorrow…

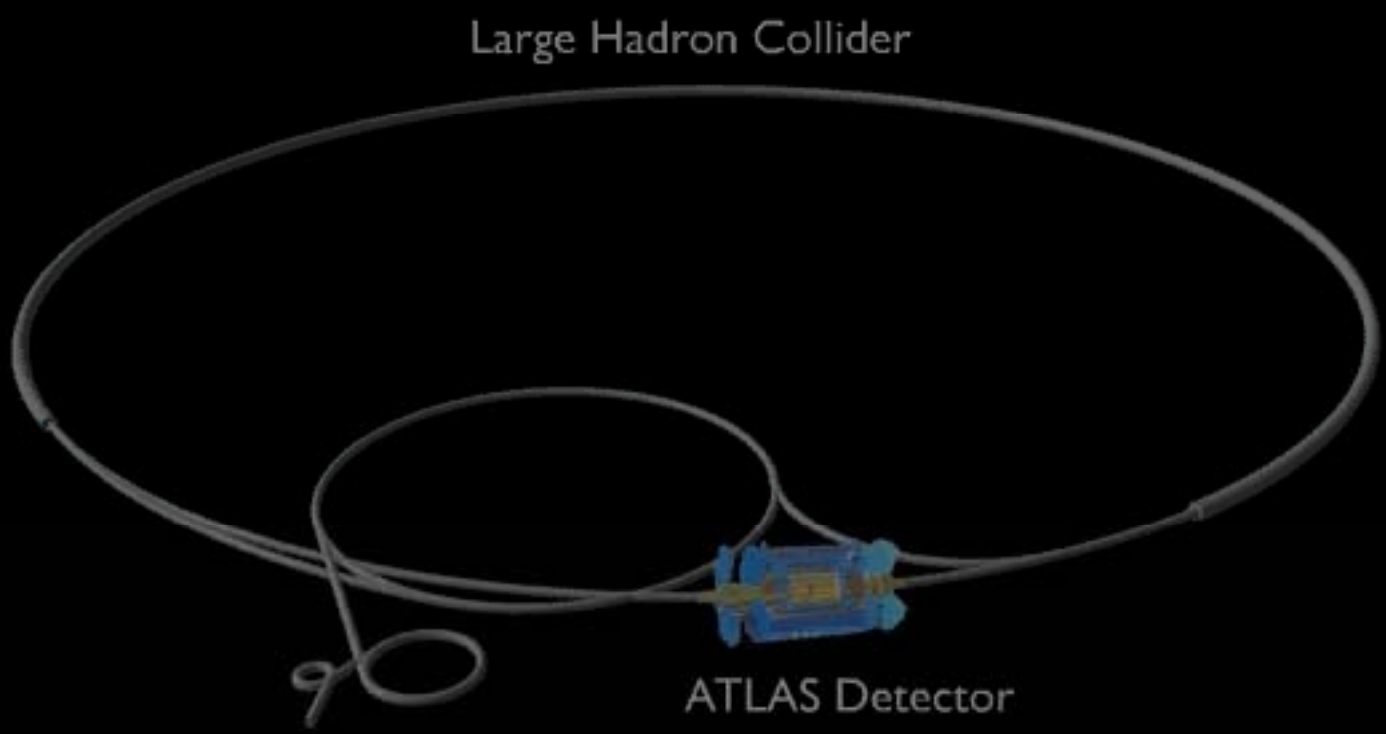


From mini-Einstein workshops for five to sixes, through to professional schools in physics, accelerator science and IT, CERN plays a valuable role in building enthusiasm for science and providing formal training..

“Compact” Detectors!



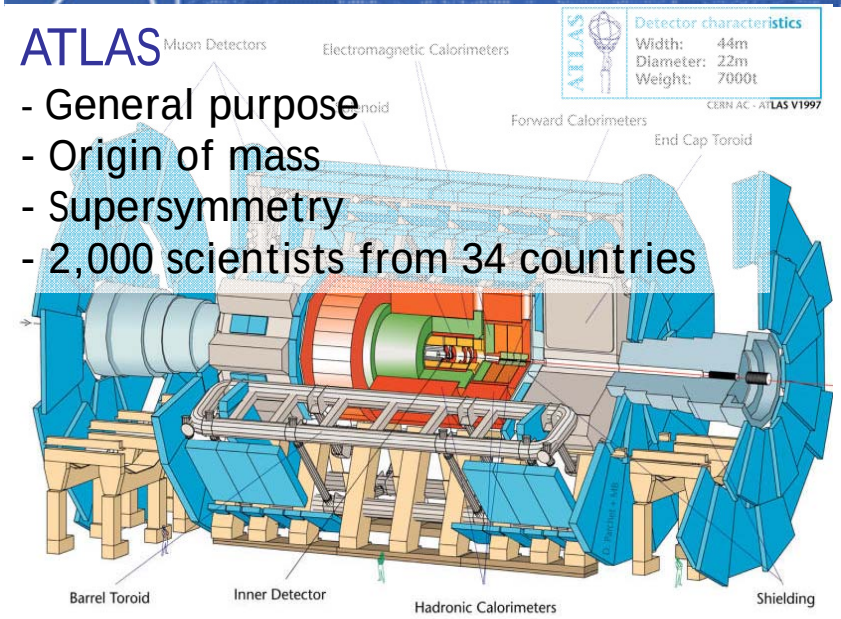
PLAY



The Four LHC Experiments...

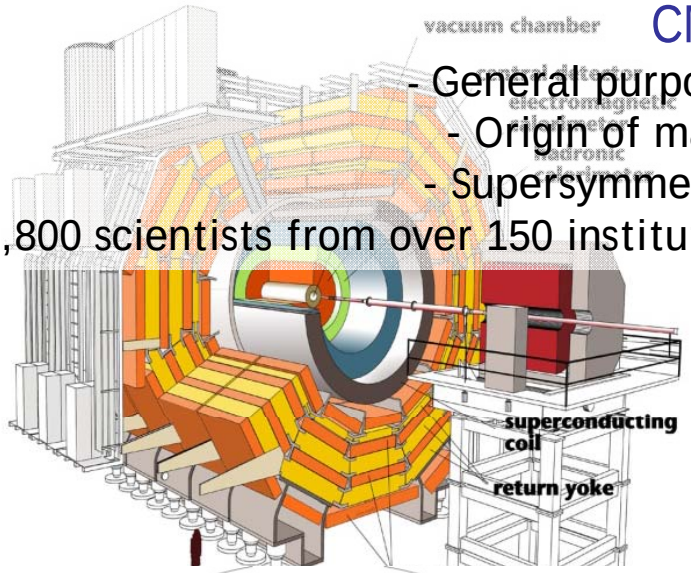
ATLAS

- General purpose
- Origin of mass
- Supersymmetry
- 2,000 scientists from 34 countries



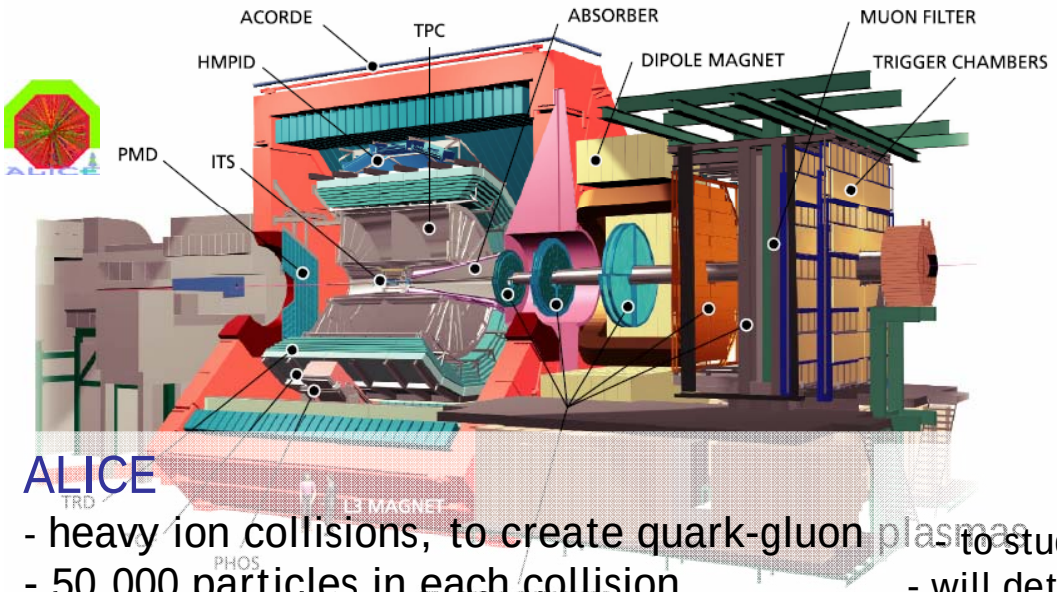
CMS

- General purpose
- Origin of mass
- Supersymmetry
-1,800 scientists from over 150 institutes



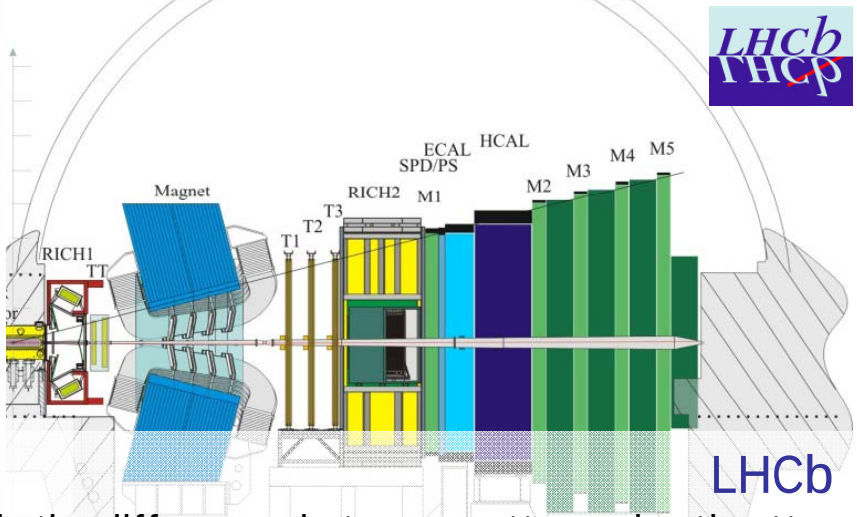
ALICE

- heavy ion collisions, to create quark-gluon plasmas
- 50,000 particles in each collision

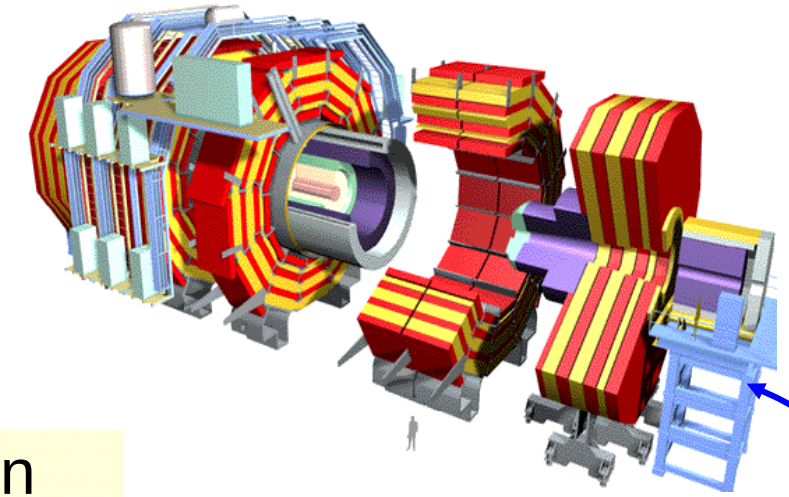


LHCb

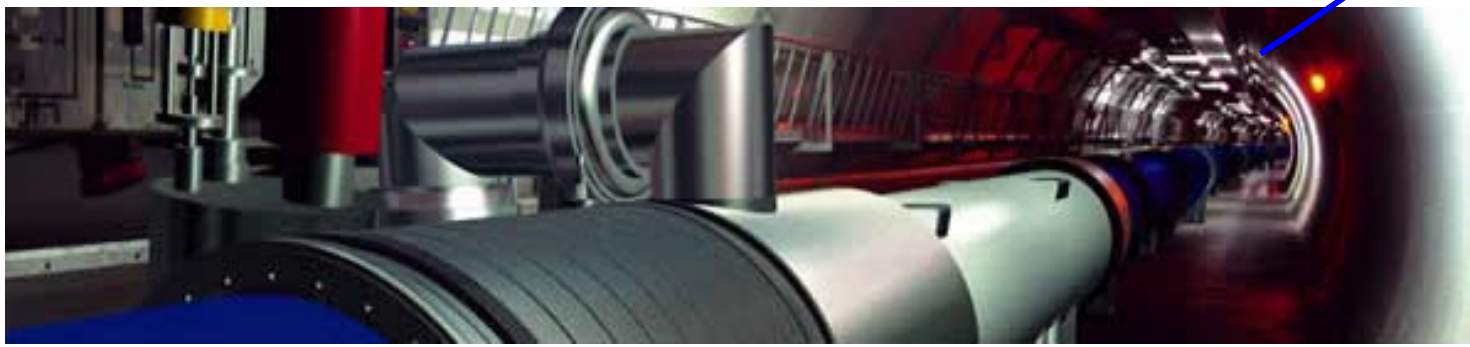
- to study the differences between matter and antimatter
- will detect over 100 million b and b-bar mesons each year



… generate lots of data …

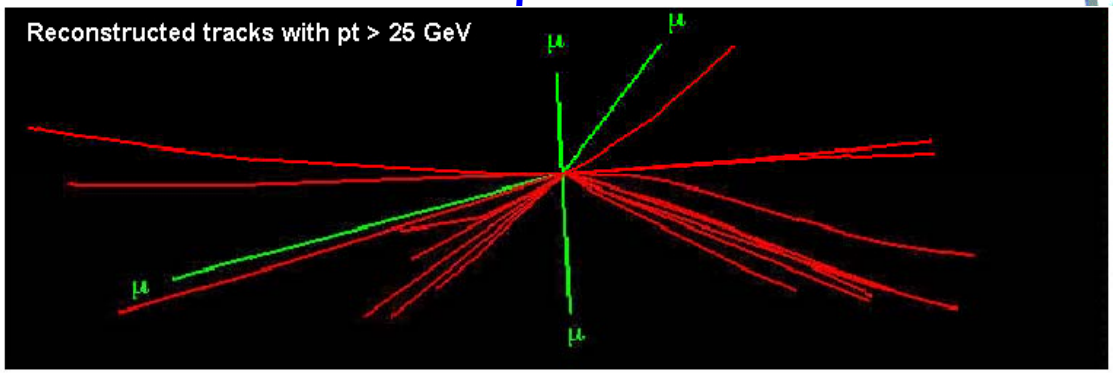


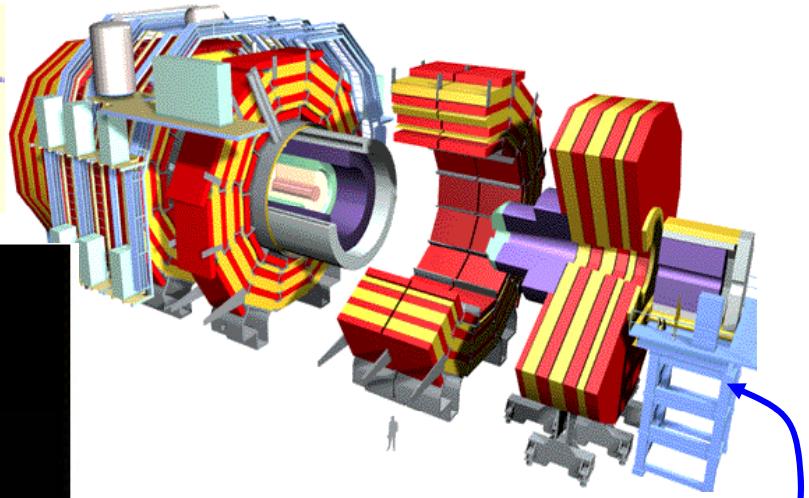
The accelerator generates 40 million particle collisions (events) every second at the centre of each of the four experiments' detectors



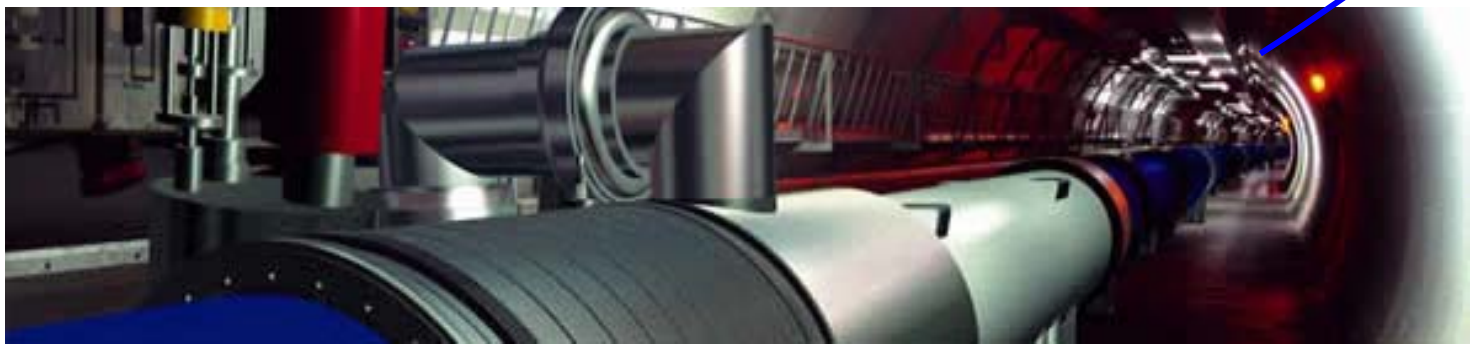
… generate lots of data …

reduced by online computers to
a few hundred “good” events
per second.

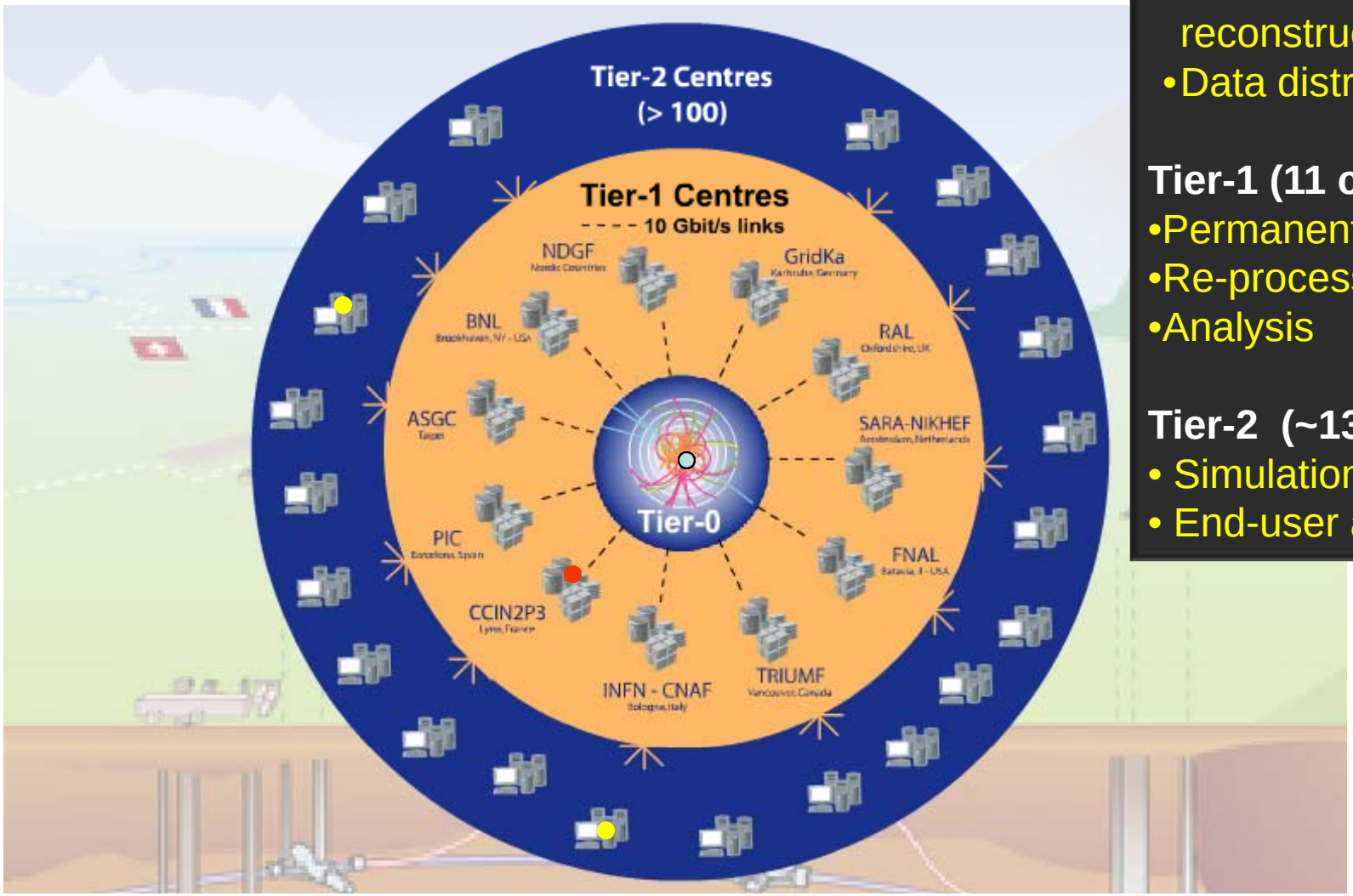




Which are recorded on disk and magnetic tape
at 100-1,000 MegaBytes/sec → **~15 PetaBytes per year**
for all four experiments



which is distributed worldwide



Tier-0 (CERN):
- Data recording
- Initial data reconstruction
- Data distribution

Tier-1 (11 centres):
- Permanent storage
- Re-processing
- Analysis

Tier-2 (~130 centres):
- Simulation
- End-user analysis

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LHC Operations

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Dataflows and rates

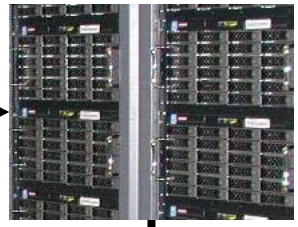
Scheduled work only!

1000MB/s

420MB/s

1100MB/s

(2000MB/s)



1520MB/s

(2500MB/s)

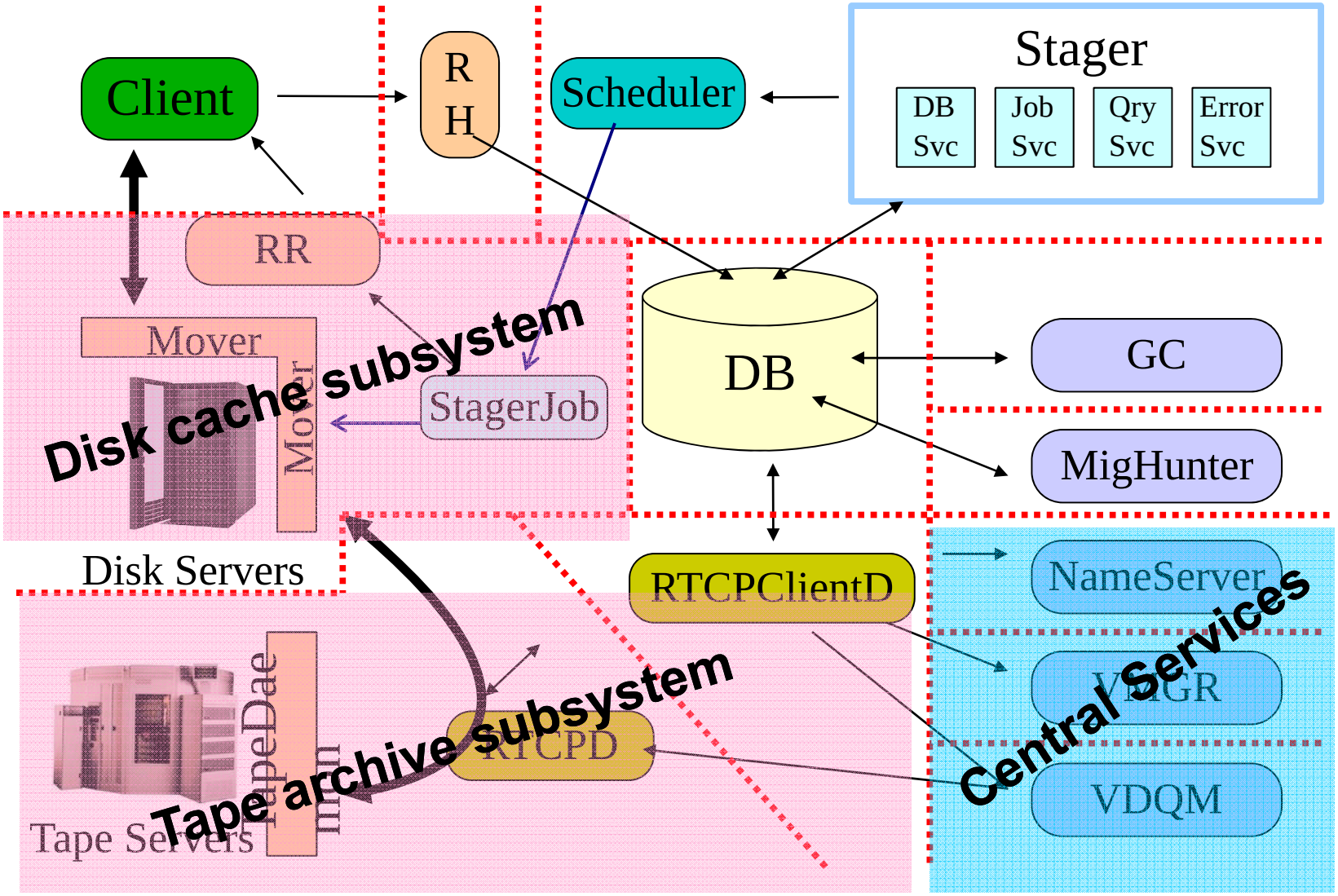
Averages! Need to be able to support 2x for recovery!

1600MB/s

Remember this figure

Castor

CASTOR
CERN Advanced STORage manager



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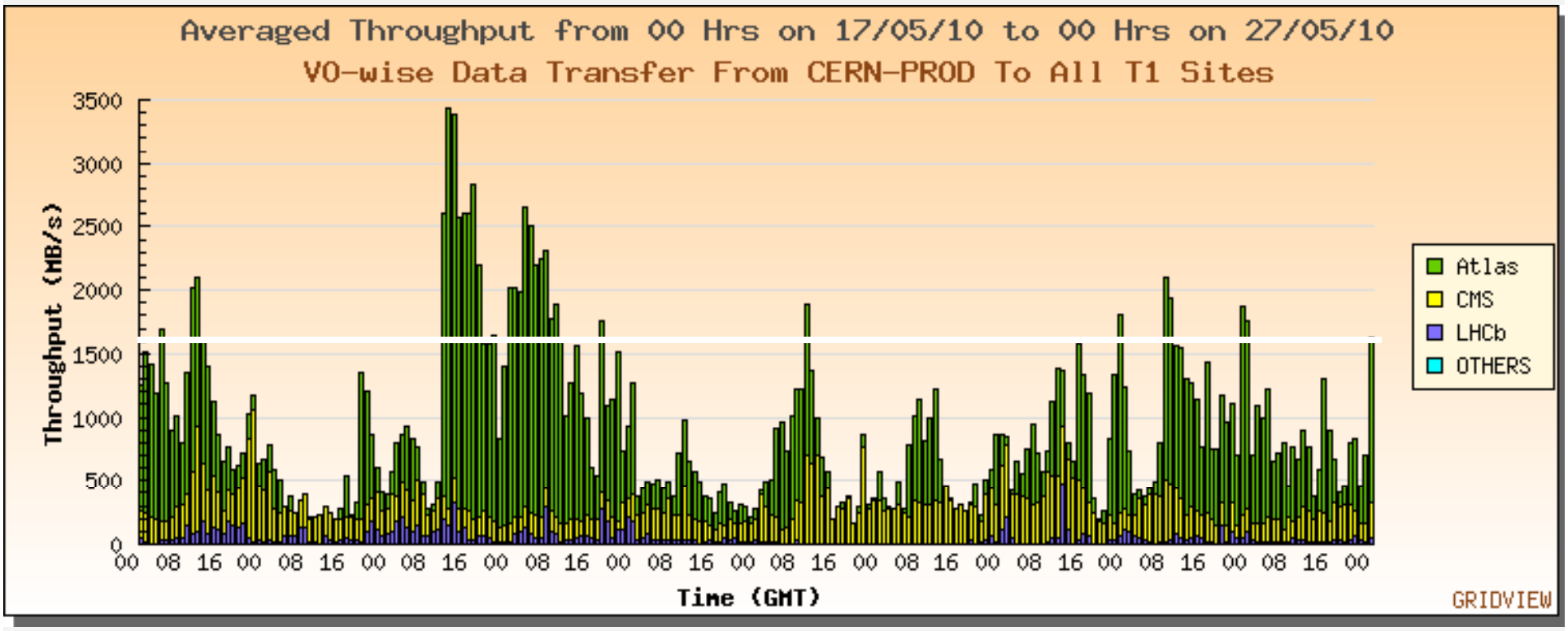

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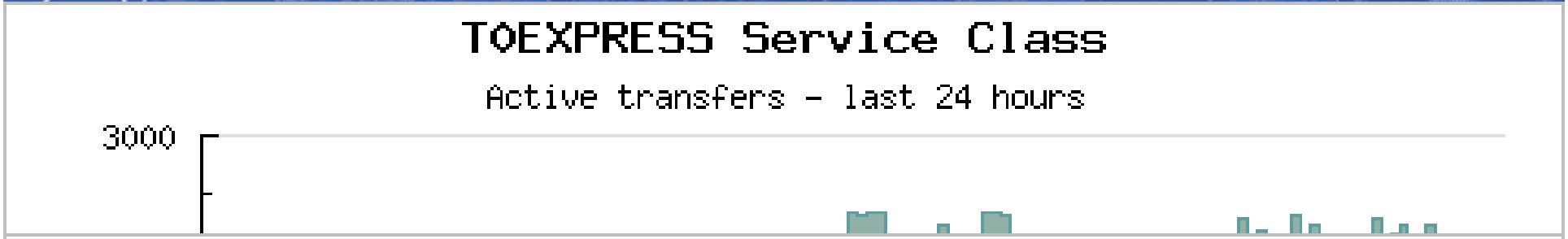
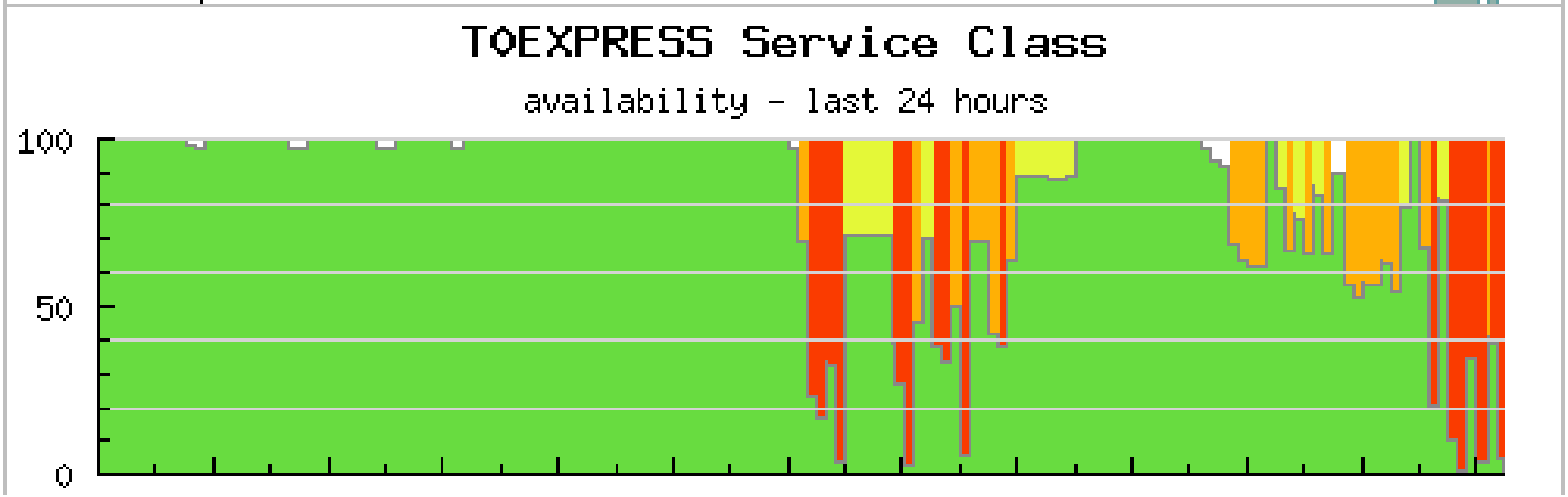
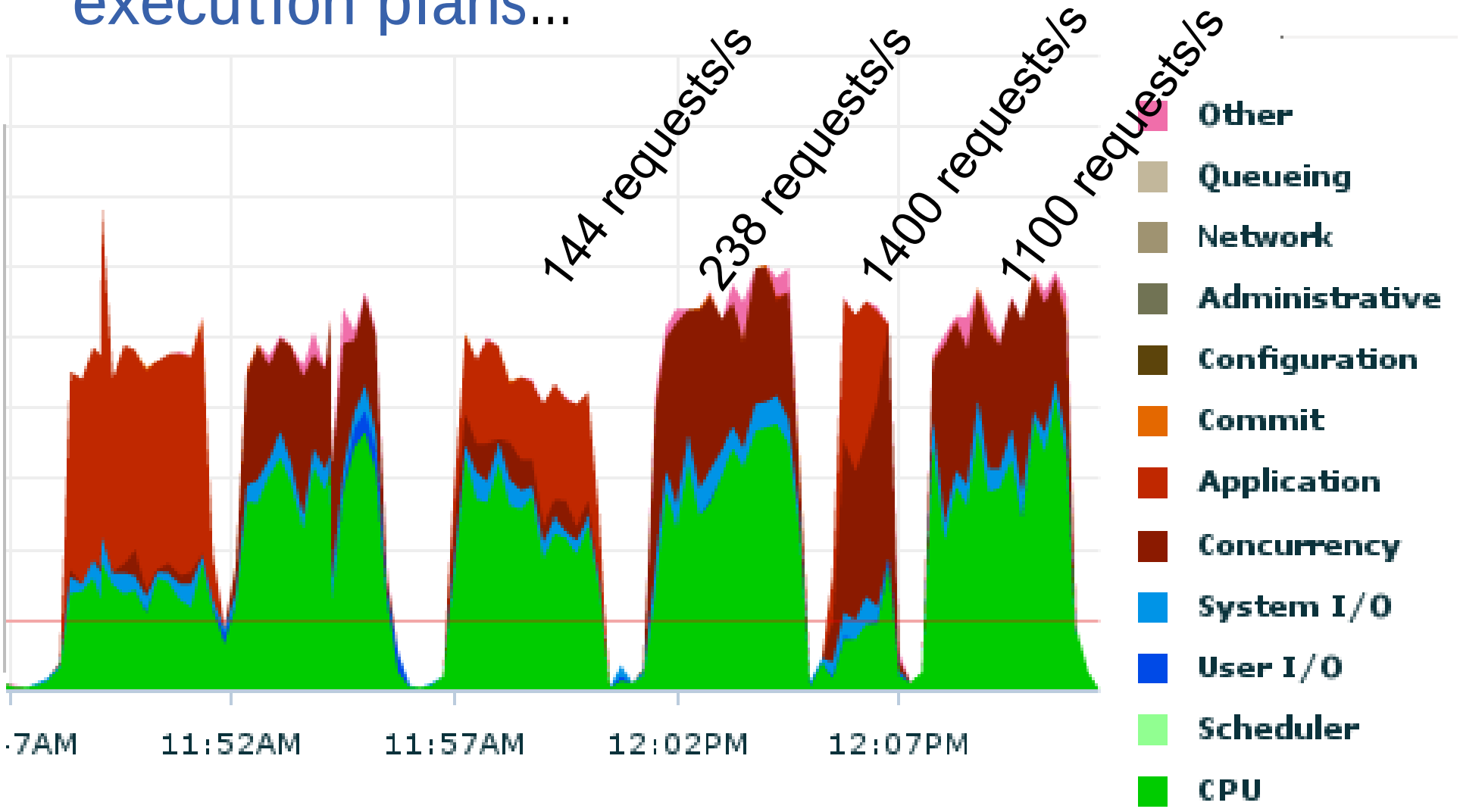




The real challenge? Users!

- Such user behaviour can affect Oracle execution plans...



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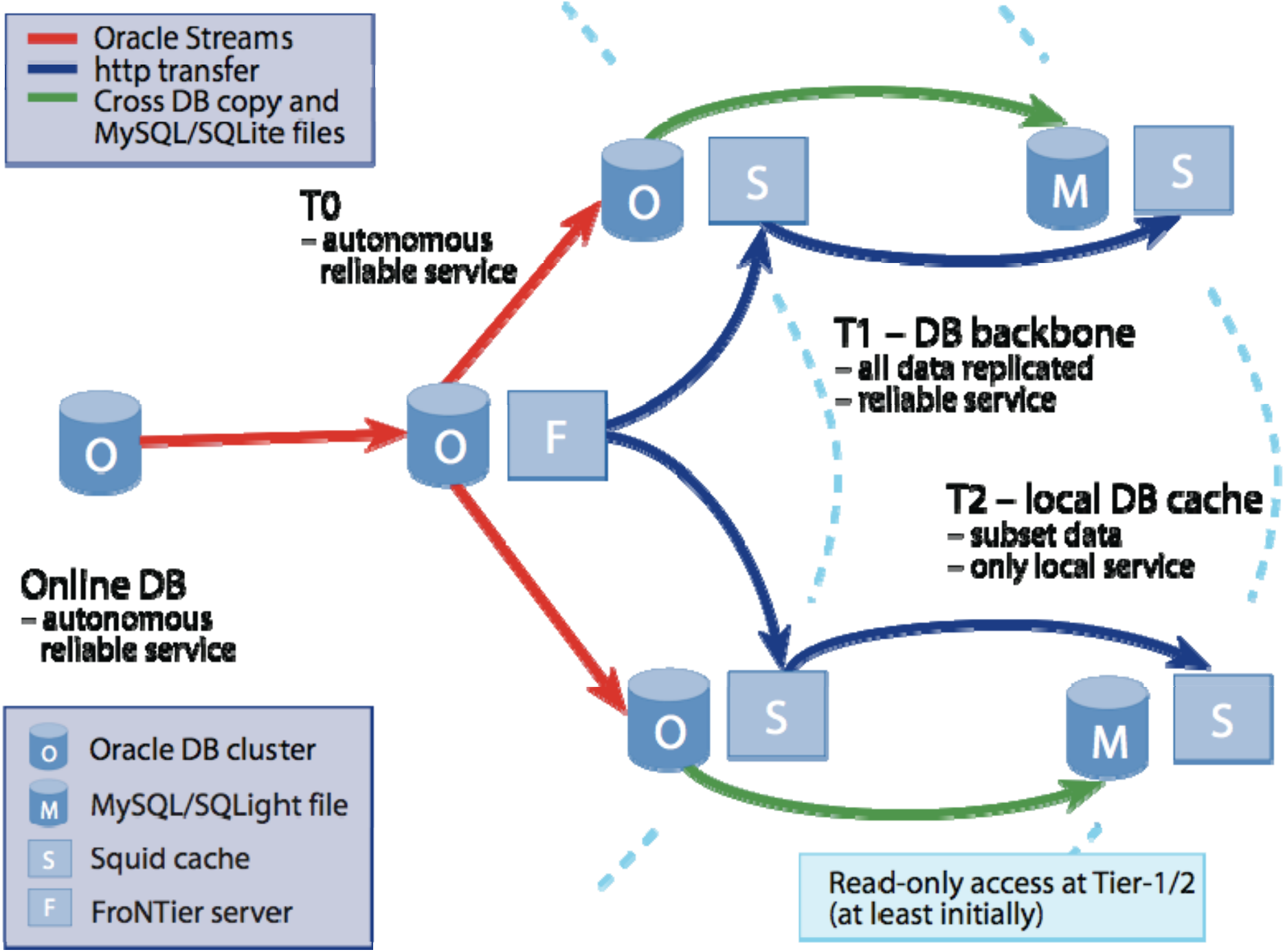
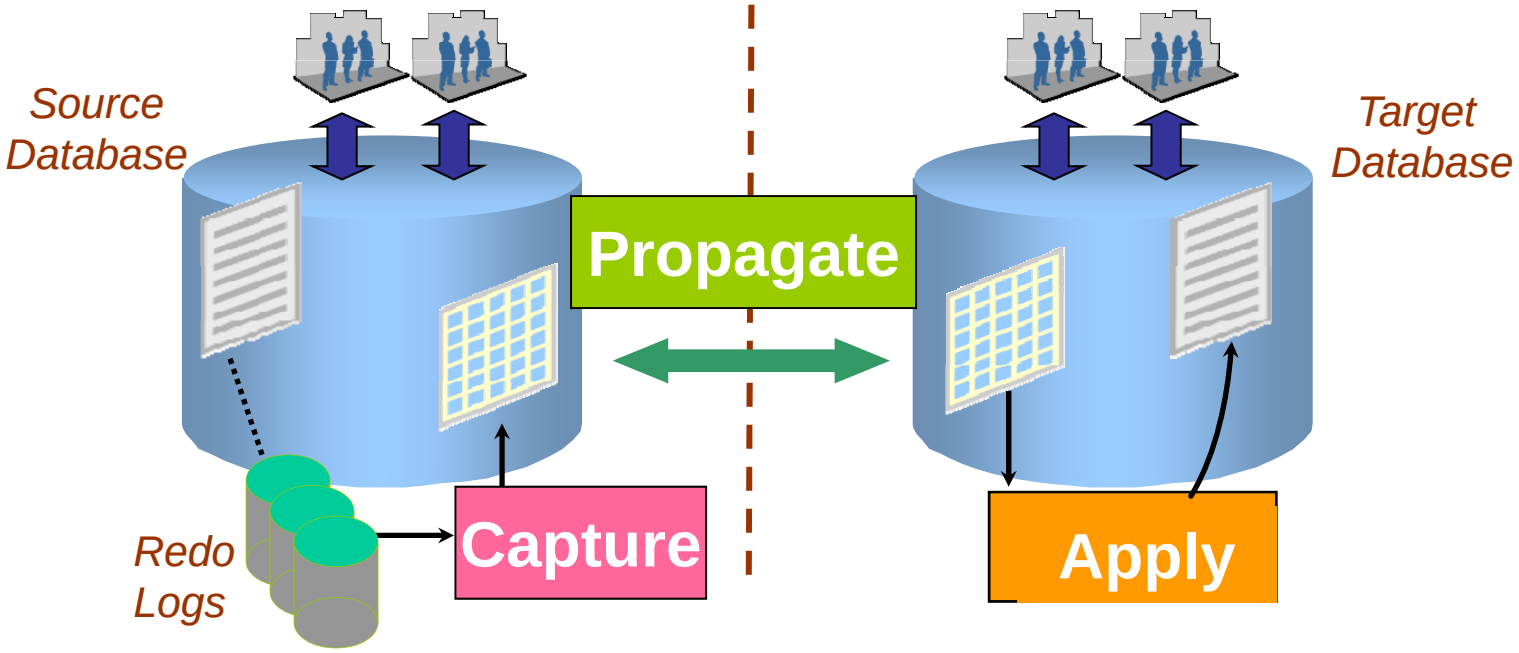
Metadata Distribution

- To make sense of the **raw data** generated by the detectors, physicists need data about any conditions at the time it was taken that affect the **detector calibration**.
- This **conditions data** is stored in a relational database and needs **distributing to Tier1 centres** to enable future reprocessing of the raw data.
- **Oracle Streams** enables this distribution…

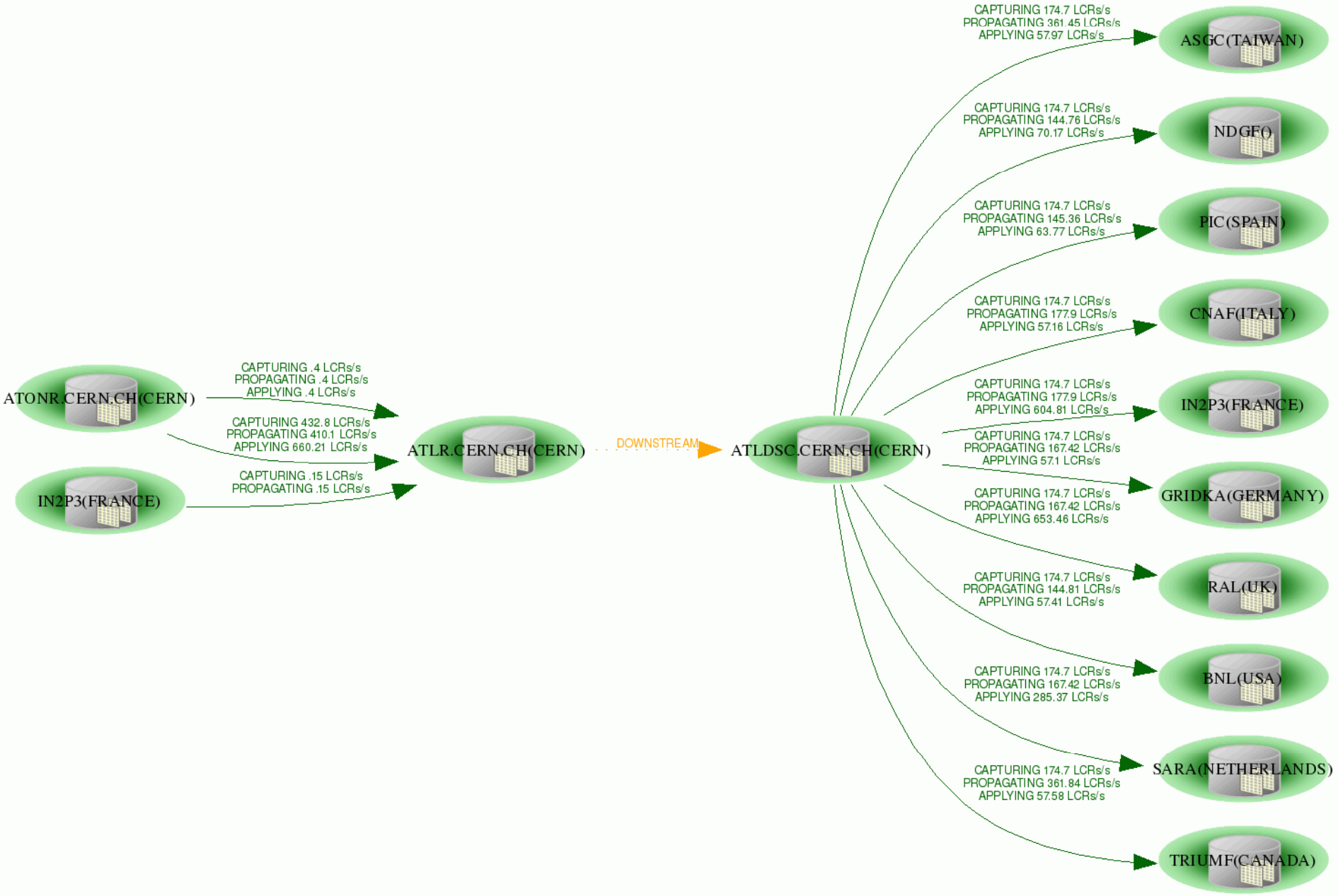

Oracle Streams
http transfer
Cross DB copy and MySQL/SQLite files
T0
– autonomous reliable service
T1 – DB backbone
– all data replicated
– reliable service
T2 – local DB cache
– subset data
– only local service
Online DB
– autonomous reliable service
O
S
M
F
Oracle DB cluster
MySQL/SQLight file
Squid cache
FroNTier server
Read-only access at Tier-1/2 (at least initially)

Oracle Streams Replication

- Technology for sharing information between databases
- Database changes captured from the redo-log and propagated asynchronously as Logical Change Records (LCRs)



Streams setup for ATLAS



Metadata Distribution

- To make sense of the **raw data** generated by the detectors, physicists need data about any conditions at the time it was taken that affect the **detector calibration**.
- This **conditions data** is stored in a relational database and needs distributing to Tier1 centres to enable future reprocessing of the raw data.
- **Oracle Streams** enables this distribution…
- We will be evaluating **GoldenGate** in the near future as this offers greater flexibility.

Outline

- Introduction to CERN, Experiments & Data
- Challenges
  - The users again…
- Summary/Conclusion

Database SERVICES

At the heart of CERN, LHC and Experiment Operations

CERN IT Department

http://cern.ch/it-dep/db/

IT/DB GROUP

Experiment Offline Databases
9 Production DBs, 7 Integration DBs
5 Tests DBs, 7 Standby DBs

Streams

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4 Production DBs

Data

CASTOR
CERN Advanced STORage manager
21 Production DBs
4 Development DBs

RAW Data

Middleware
73 Application Servers

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17 Production DBs
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Accelerators ACC
12 Production DBs

LHC Operations

Streams

Tier-1 Centres
dedicated 10 Gbit/s links
NDGF, GridKa, BNL, RAL, ASGC, SARA-NIKHEF, PIC, FNAL, CCIN2P3, INFN - CNAF, TRIUMF

LHC Experiments
LHCb
CMS
ATLAS
ALICE

PARTNERS:
CERN openlab
ORACLE

CERN

Databases for Accelerators

ORACLE Enterprise Manager 10g
Grid Control

Home | Targets | Deployments | Alerts | Comp

Hosts | Databases | Middleware | Web Applications | Services | Systems | Groups | All Targets

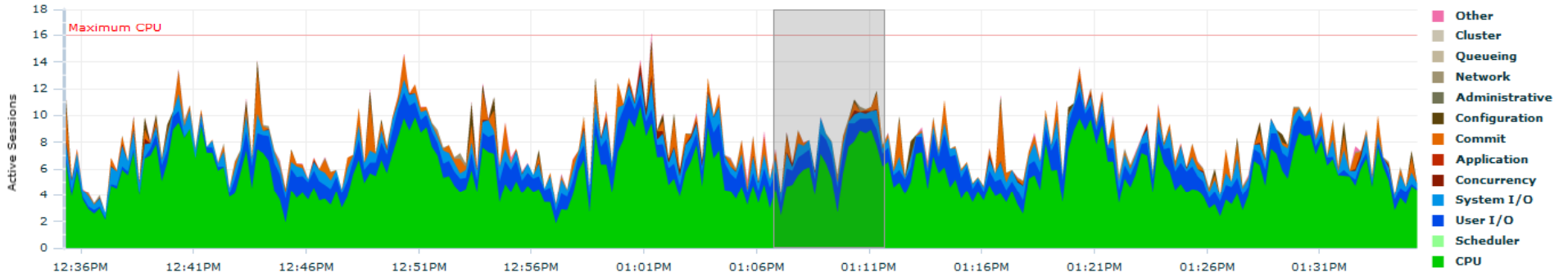
Cluster: accmeas_cluster > Cluster Database: ACCMEAS.cern.ch > Database Instance: ACCMEAS.cern.ch_ACCMEAS3 >

Top Activity

Switch Database Instance ACCMEAS

Drag the shaded box to change the time period for the detail section below.

View Data Re



Detail for Selected 5 Minute Interval

Start Time **30-Mar-2010 13:06:47 o'clock MEST**

Top SQL

Actions Schedule SQL Tuning Advisor Go

Select All | Select None

Select	Activity (%)	SQL ID	SQL Type
	16.98	3guzpbs8t9r6q	SELECT
	12.95	3pkrm4ccbknta	INSERT
	12.91	3k1gkn3n5sr2b	189
	11.55	2a6aduxkh4apt	SELECT
	11.12	2bwzcbnwk1awz	SELECT
	6.78	c8rkrrfxcnmg3	SELECT
	5.73	7pd3cywtvut4b	SELECT
	5.21	gjugsph43w51v	SELECT
	2.71	dwvnh1mnszgxs	SELECT
	1.01	7jbtz6rngdv4z	PL/SQL EXECUTE

Actions Schedule SQL Tuning Advisor Go

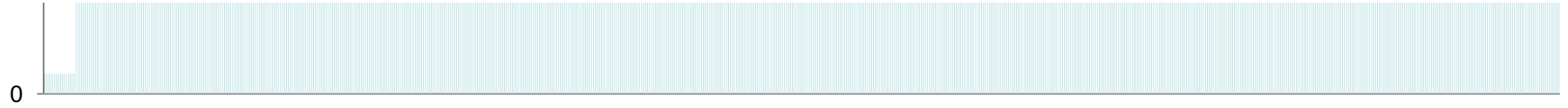
Total Sample Count: 2,285

Top Sessions

View Top Sessions

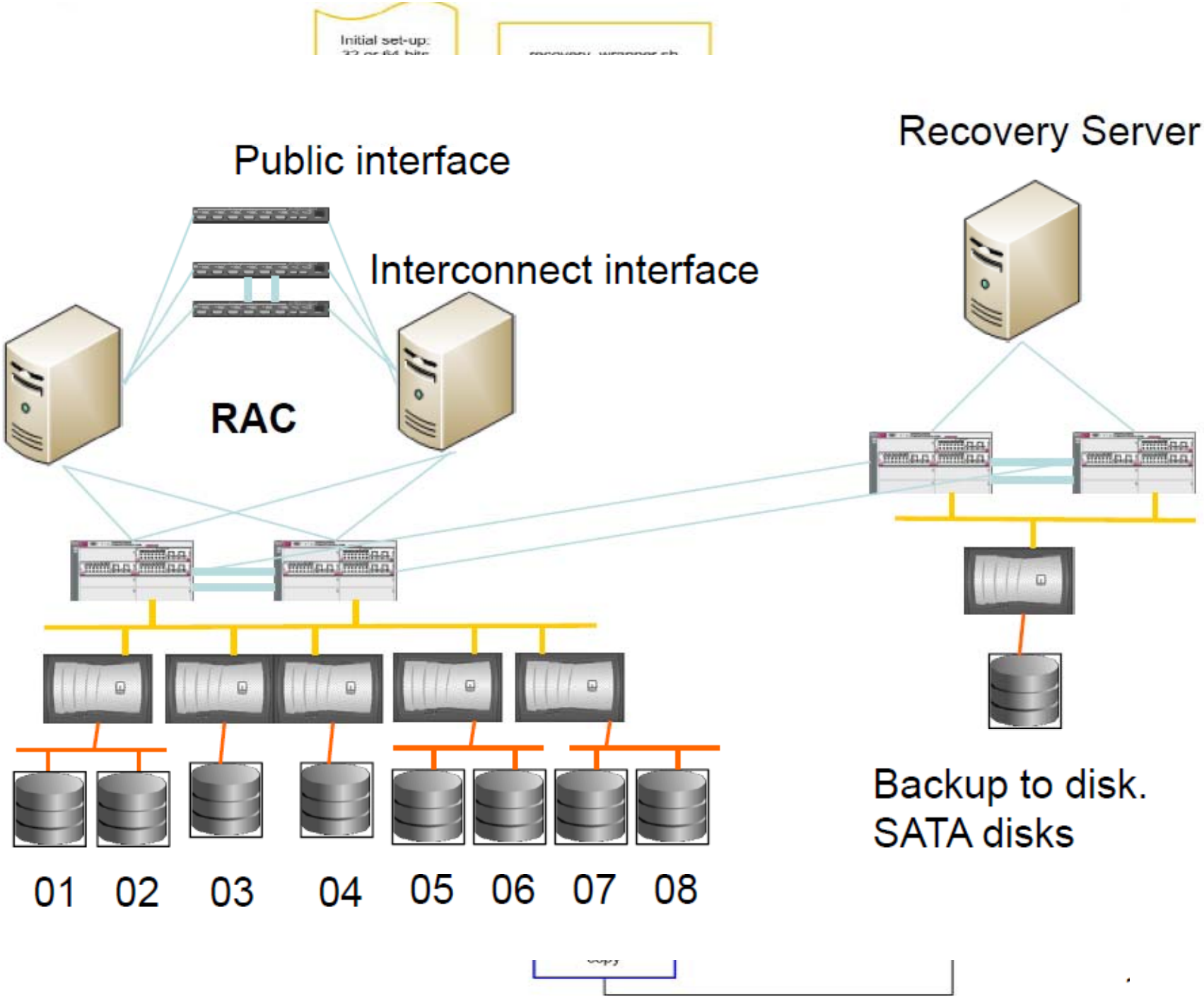
Activity (%)	Session ID	User Name	Program
9.56	508	MEASDB	
7.68	528	MEASDB_PUB	python@cs-ccr-abbi2 (TNS V1-V3)
7.18	503	MEASDB	
5.30	441	MEASDB	
5.07	491	MEASDB	
4.88	281	MEASDB	oracle@dbsrva251.cern.ch (J001)
3.95	279	MEASDB	
3.69	398	MEASDB	
3.65	33	MEASDB	
2.99	298	SYS	oracle@dbsrva251.cern.ch (LGWR)

Total Sample Count: 2,605



Backups: A digression

- **Backing up** databases is a **chore**, not a **challenge**…
- …the challenge is to **recover** a database…
  - … and this had better be rare, not a chore!
- To help reduce the challenge of, and increase confidence in, recovery procedures, we have developed an **automated recovery test tool**.


Initial set-up:
Recovery Server
Public interface
Interconnect interface
RAC
Backup to disk.
SATA disks
01
02
03
04
05
06
07
08

Backups: A digression

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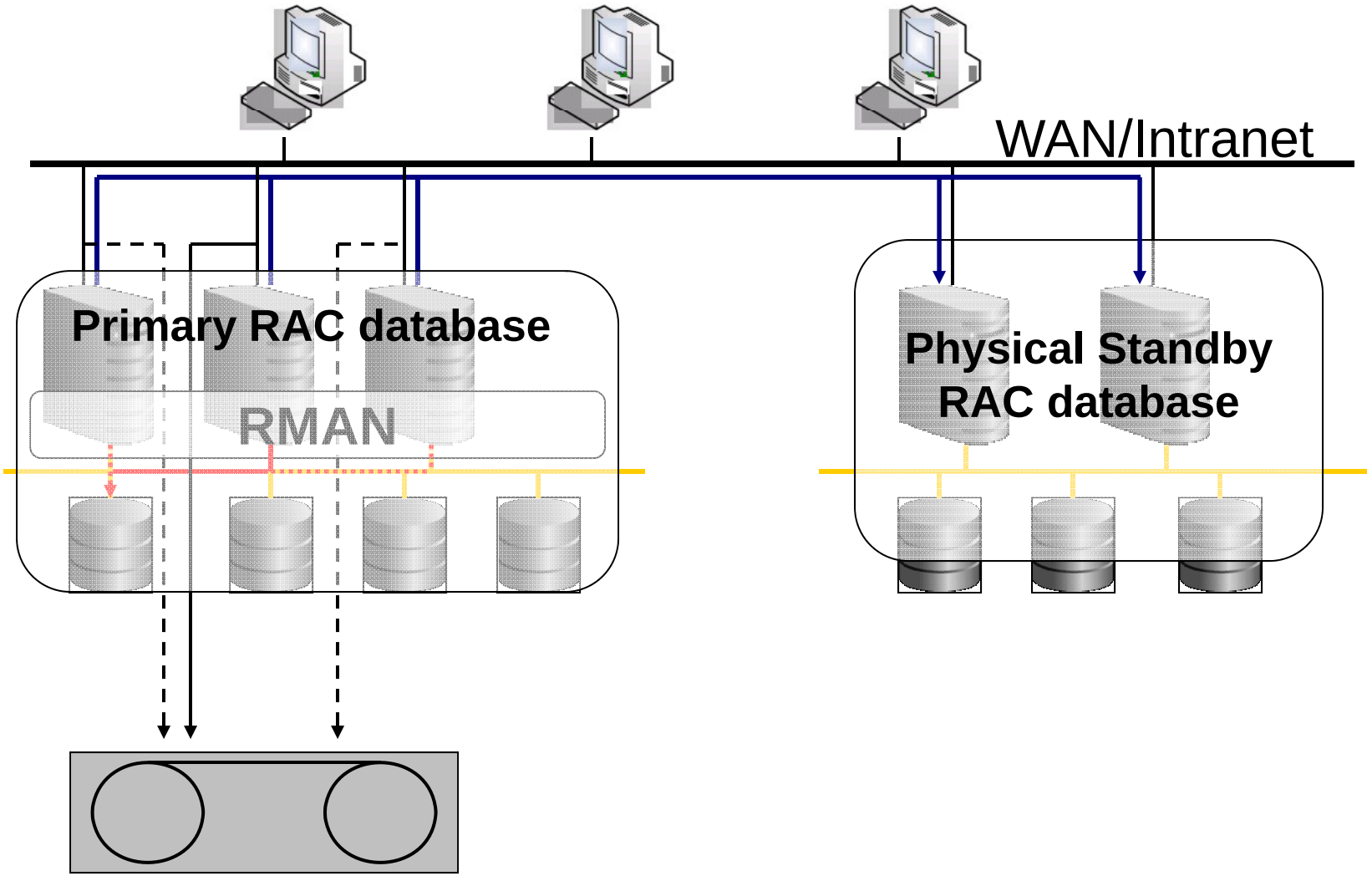
- …the challenge is to **recover** a database…
  - … and this had better be rare, not a chore!
- To help reduce the challenge of, and increase confidence in, recovery procedures, we have developed an **automated recovery test tool**.
- Problem: days to recover some databases
  - At least 2.5 days for *partial restore* of the critical database for accelerator operations…

➲use Data Guard to create standby databases.



We are extremely keen to migrate to 11g and exploit Active Data Guard!

Outline

- Introduction to CERN, Experiments & Data
- Challenges
  - Virtualisation & Fabric Management
- Summary/Conclusion

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INFN - CNAF
TRIUMF

LHC Experiments
LHCb
CMS
ATLAS
ALICE

EDMS

PARTNERS:
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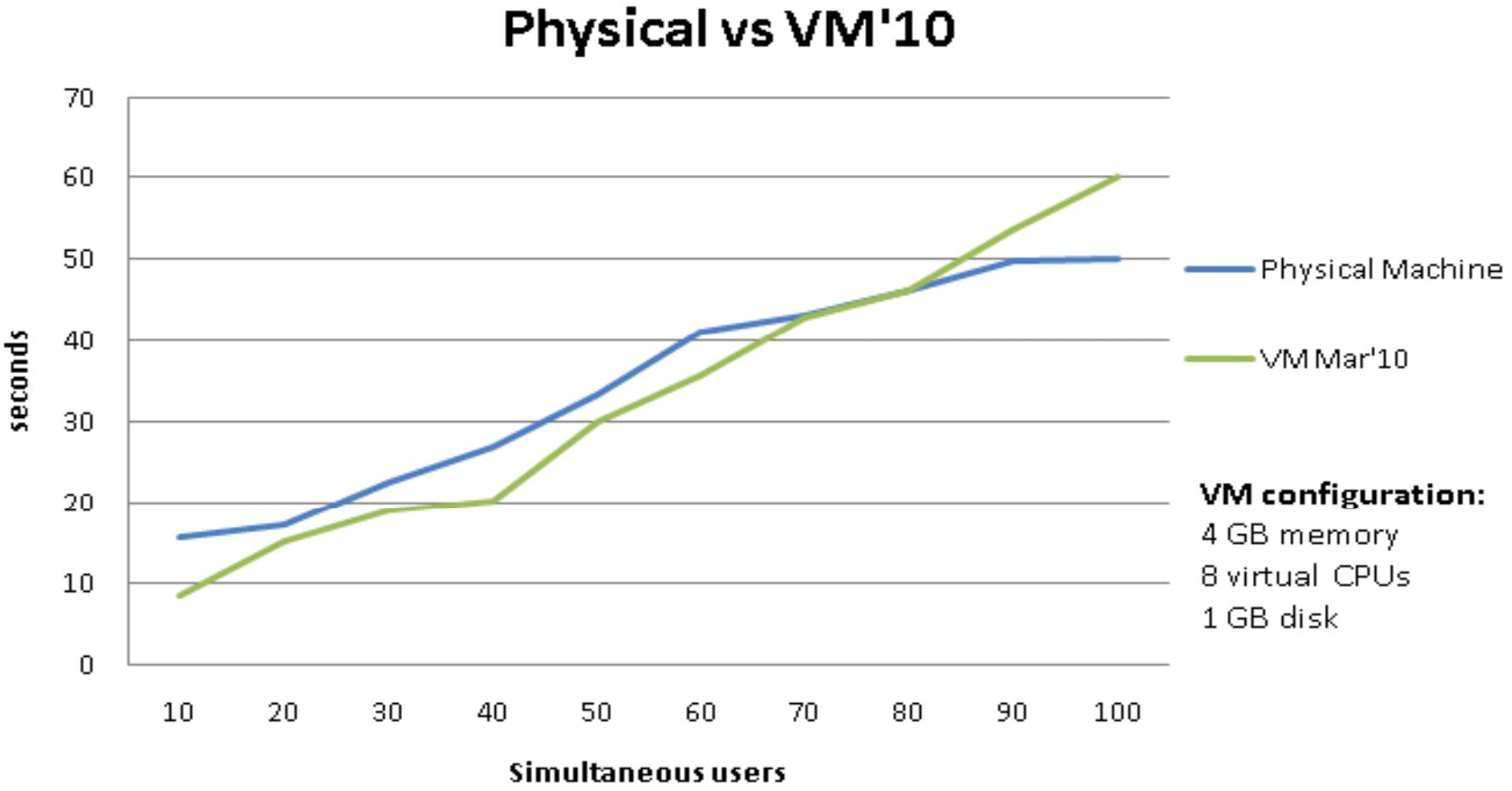
Size isn't all...

- As well as being **vital for accelerator and experiment operations**, Oracle databases also **underpin CERN's administrative applications**.
- Individual databases are **small**, but we have **many servers**
- Average load is **very low**, so **clear opportunity for server consolidation** with **virtualisation**.
- Excellent results from tests with Oracle VM and Web Logic Server virtual edition.

Physical vs Virtual



- Comparison of a Physical Machine (4GB memory, 8 cores) running WebLogic Server versus a Virtual Machine (4GB memory, 8 Virtual CPUs) running WebLogic Server – Virtual Edition
- An unreleased version of the kernel of JRockit has been used for this tests.

Fabric Management

- As most large organisations, CERN has **standards and procedures** for network and system configuration.
- "Easy to install" applications can be good, but they should be **configurable** to work correctly in a tightly managed environment.
- **Good collaboration around Oracle VM**
  - e.g. IP/MAC address binding, assumptions about NFS as shared file system.

Outline

- Introduction to CERN, Experiments & Data
- Challenges
  - Monitoring
- Summary/Conclusion

Database SERVICES

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CERN IT Department

http://cern.ch/it-dep/db/

Service Level Status overview

Home | Search | KPIs | Tags | Admin | Documentation | Help

Services provided by IT/DB group

28 May 2010 Fri 14:24:46

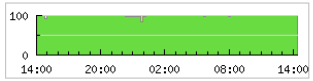
IT/DB services

availability: (more)
percentage: 99%
status: **available**

this service consists of:

- Accelerator databases
- AIS databases
- EDMS databases
- General purpose databases
- IT infrastructure databases
- CASTOR and SRM databases
- ALICE databases
- ATLAS databases
- CMS databases
- LHCb databases
- Other experiments databases
- WLCG database
- Physics DB Streams
- J2EE Public Service
- EDMS Service
- RMAN Jobs

availability in the last 24 hours (more):



Additional information

full name: **Services provided by IT/DB group**
short name: IT/DB services
group: IT-DB
email: **Helpdesk@cern.ch**
service managers: Eric Grancher, Nilo Segura Chinchilla, Eva Dafonte Perez

Availability update

last update: 14:16:53, 28 May 2010 (8 minutes ago)
expires after: 57 minutes
rss feed with status changes

Part of (subservice of):

none / not declared

Admin

admin tools

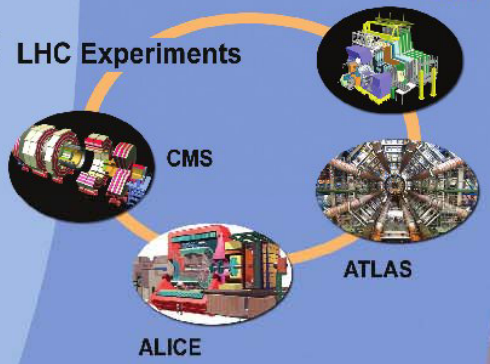
SLS by CERN IT/CF — SLS.Support@cern.ch

Streams

Tier-1 Centres

RAW Data

LHC Experiments



Middleware

73 Application Servers

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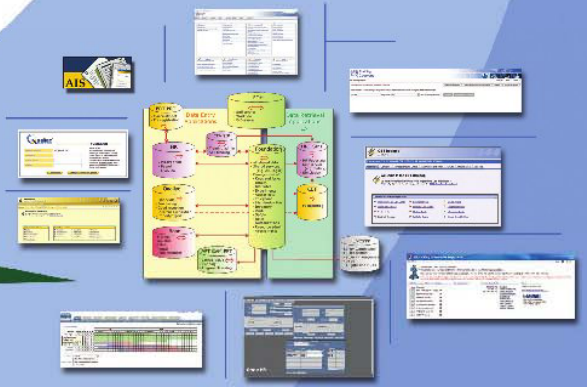

PARTNERS:

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CERN

Up and seen to be up

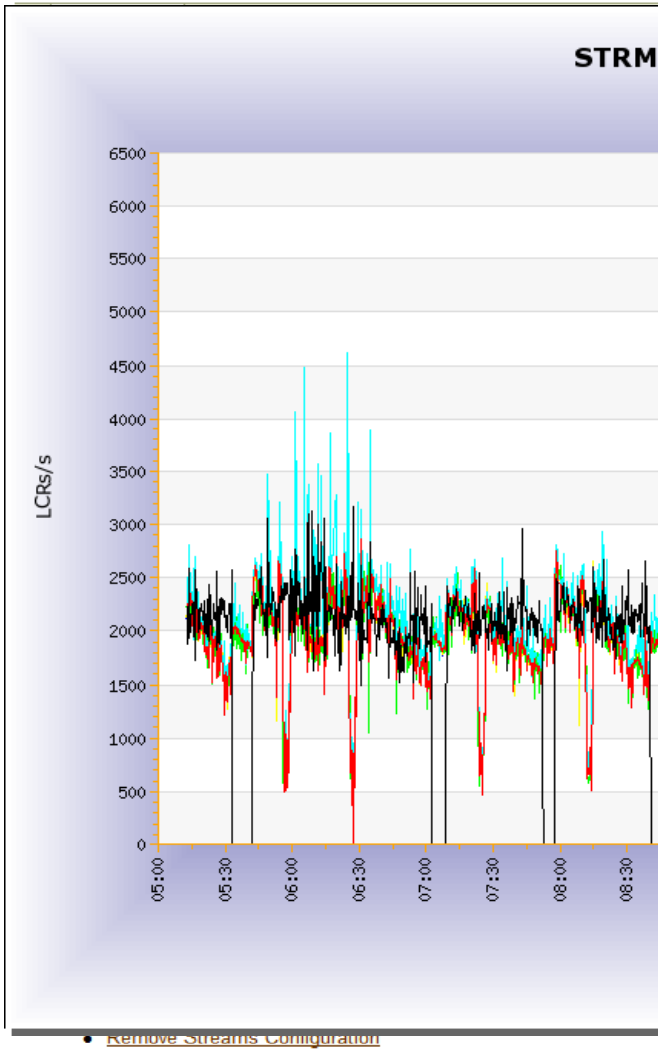
- **Understanding the current state** of our many database servers and applications is a **major challenge**.
- **Collaboration around Oracle Enterprise Manager** has been a really fruitful aspect of the CERN openlab partnership with Oracle.
- Many tools developed at CERN for monitoring Streams have led to features in OEM 10.2 and 11.1.

ORACLE Enterprise Manager 10g
Grid Control

Hosts | Databases | Middleware | Web Applications | Services |

Cluster: strmdsc > Cluster Database: atldsc.cern.ch >

Streams



- Remove Streams Configuration

Home | Targets | Depl

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Other names may be trademarks of their respective owners.
About Oracle Enterprise Manager

Monitor | Maps | DBs | **Streams** | Plots | Errors | Availability | History | Reports

STREAM DETAILS

SOURCE	ATLDSC.CERN.CH

CAPTURE

Name	STREAMS_CAPTURE
SCN read	6110514671773
LCRs captured	135508158 (981.91 /s)
SCN captured	6110514662689
LCRs enqueued	4098569 (39.25 /s)
SCN enqueued	6110514662572
Capture Latency	33 sec
Info	ATLDSC.CERN.CH
State	CAPTURING CHANGES
Error Time	
Error Msg	

QUEUE

Name	STRM_QUEUE_CA
Id	42947
Outstanding Msg	24
Cumulative Msg	6223281 (38.69 /s)
Cumulative Msg Spilled	2693626 (0 /s)

PROPAGATION

Name	STRM_PROPAGATION_GRIDKA
LCRs Propagated	3783492 (38.65 /s)
Bytes Propagated	0 (0 /s)
State	ENABLED
Error Time	
Error Msg	

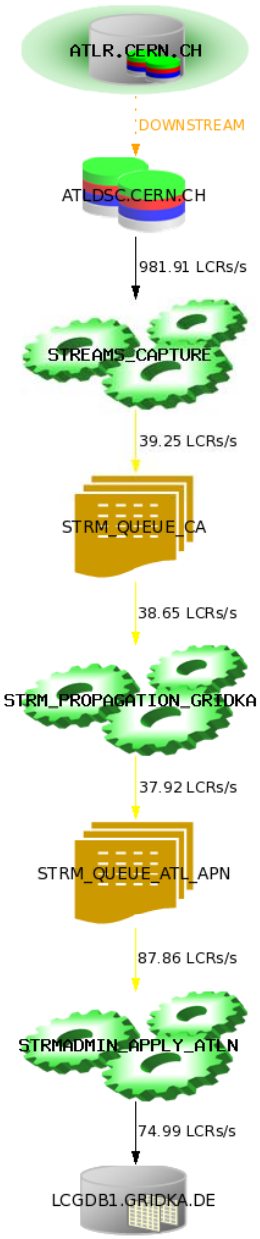
DESTINATION	LCGDB1.GRIDKA.DE

QUEUE

Name	STRM_QUEUE_ATL_APN
Id	198958
Outstanding Msg	0
Cumulative Msg	240899548 (37.92 /s)
Cumulative Msg Spilled	53380 (0 /s)

APPLY

Name	STRMADMIN_APPLY_ATLN
LCRs Dequeued	240899548 (87.86 /s)
Total LCRs Applied	235085002 (74.99 /s)
SCN Dequeued	6110514660055
Dequeue Latency	27 sec
Transaction Received	4435350
Transaction Assigned	4435352
Transaction Applied	4435350
State	IDLE
HWM SCN	6110514639800
HWM Apply Latency	33 sec
Last applied LCR	2010-05-27 16:18:04 (11 sec ago)
Data Latency	33 sec
Error Time	
Error Msg	



27-05-10 16:18:21 auto refresh ☑

Up and seen to be up

- **Understanding the current state** of our many database servers and applications is a **major challenge**.
- **Collaboration around Oracle Enterprise Manager** has been a really fruitful aspect of the CERN openlab partnership with Oracle.
- Many tools developed at CERN for monitoring Streams have led to features in OEM 10.2 and 11.1.
- As in the fabric management area, integration with other tools is desirable. A future challenge?

Oracle Enterprise Manager (ATOPUROV) - User-Defined Numeric Metric: Script SESSIONS_LIMIT_IDLE_2H: Last 24 hours - Mozilla Firefox

File Edit View History Bookmarks Tools Help

https://oms.cern.ch/em/console/monitoring/metricDetail$metricColumn=NumValue$metric=SQLUDM$type=oracle*_database$target=AISDBP.WORLD*_AISDBP3$keyValue=SESSIONS*_LIMIT*_IDLE*_2H$pageType=byDay$c

Most Visited AntonTopurovSandbo... ViewDB CERN IT-DES Change ... DAM admin Global - Aggregates, A... IT Service Status Board

ORACLE Enterprise Manager 10g
Grid Control

Setup Preferences Help Logout

Home | Targets | Deployments | Alerts | Compliance | Jobs | Reports

Hosts | Databases | Middleware | Web Applications | Services | Systems | Groups | All Targets

Database Instance: AISDBP.WORLD_AISDBP3 > User-Defined Metrics >

User-Defined Numeric Metric: Script SESSIONS_LIMIT_IDLE_2H: Last 24 hours

Last Updated 27-May-2010 18:32:57 MEST

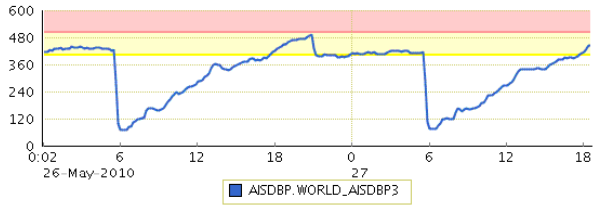
View Data Last 24 hours

Script SESSIONS_LIMIT_IDLE_2H

Statistics

Last Known Value	448
Average Value	339.33
High Value	493
Low Value	79
Warning Threshold	400
Critical Threshold	500
Occurrences Before Alert	1
Corrective Action	None

Metric Value



Alert History

Comment for Most Recent Alert [ ] Add Comment

Severity	Timestamp	Message	Last Comment	Details
⚠	27-May-2010 17:42:57	UDM alert (SESSIONS_LIMIT): key = %Key, value = 406		-
✓	27-May-2010 05:42:57	CLEARED - UDM alert (SESSIONS_LIMIT): key = %Key, value = 283		-
⚠	26-May-2010 23:52:57	UDM alert (SESSIONS_LIMIT): key = %Key, value = 407		-
✓	26-May-2010 22:52:57	CLEARED - UDM alert (SESSIONS_LIMIT): key = %Key, value = 395		-
⚠	26-May-2010 21:52:57	UDM alert (SESSIONS_LIMIT): key = %Key, value = 406		-
✓	26-May-2010 21:22:57	CLEARED - UDM alert (SESSIONS_LIMIT): key = %Key, value = 397		-
⚠	26-May-2010 17:42:57	UDM alert (SESSIONS_LIMIT): key = %Key, value = 408		-

Related Links

Acknowledge
Compare Objects Script
Compare Targets
Metric and Policy Settings

Home | Targets | Deployments | Alerts | Compliance | Jobs | Reports | Setup | Preferences | Help | Logout

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About Oracle Enterprise Manager

https://oms.cern.ch/em/console/monitoring/metricDetail$metricColumn=NumValue$metric=SQLUDM$type=oracle*_database$target=AISDBP.WORLD*_AISDBP3$keyValue=SESSIONS*_LIMIT*_IDLE*_2H$pageType=byDay$ctxType=Databases#

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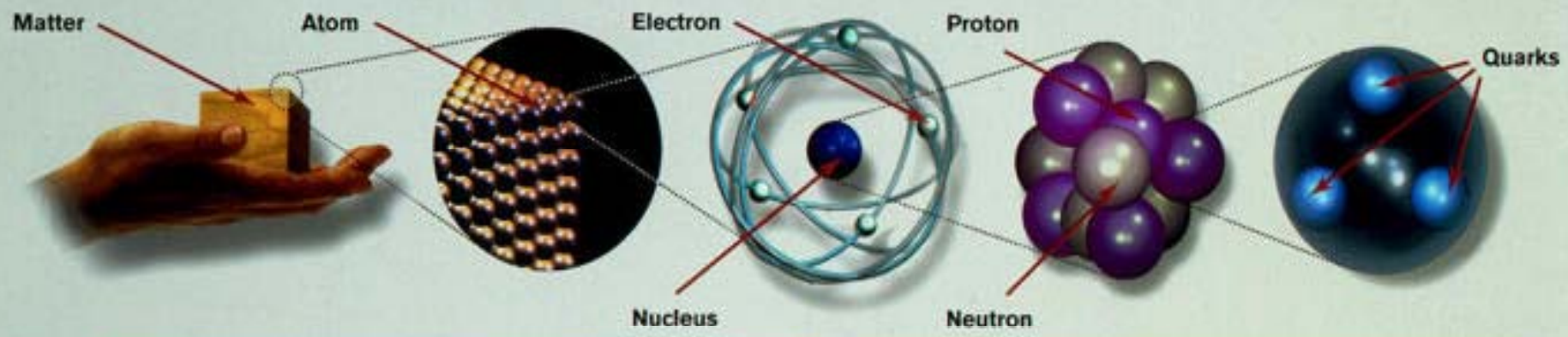

Matter particles

All ordinary particles belong to this group

These particles existed just after the Big Bang. Now they are found only in cosmic rays and accelerators

LEPTONS

FIRST FAMILY	**Electron** Responsible for electricity and chemical reactions; it has a charge of -1	**Electron neutrino** Particle with no electric charge, and possibly no mass; billions fly through your body every second
SECOND FAMILY	**Muon** A heavier relative of the electron; it lives for two-millionths of a second	**Muon neutrino** Created along with muons when some particles decay
THIRD FAMILY	**Tau** Heavier still; it is extremely unstable. It was discovered in 1975	**Tau neutrino** not yet discovered but believed to exist

QUARKS

Up Has an electric charge of plus two-thirds; protons contain two, neutrons contain one	**Down** Has an electric charge of minus one-third; protons contain one, neutrons contain two
Charm A heavier relative of the up; found in 1974	**Strange** A heavier relative of the down; found in 1964
Top Heavier still	**Bottom** Heavier still; measuring bottom quarks is an important test of electroweak theory

Force particles

These particles transmit the four fundamental forces of nature although gravitons have so far not been discovered

Gluons
Carriers of the strong force between quarks

Felt by: quarks

The explosive release of nuclear energy is the result of the strong force

Photons
Particles that make up light; they carry the electromagnetic force

Felt by: quarks and charged leptons

Electricity, magnetism and chemistry are all the results of electro-magnetic force

Intermediate vector bosons
Carriers of the weak force

Felt by: quarks and leptons

Some forms of radio-activity are the result of the weak force

Gravitons
Carriers of gravity

Felt by: all particles with mass

All the weight we experience is the result of the gravitational force

The Twenty Member States of CERN

Member States (Dates of Accession)

- AUSTRIA (1959)
- BELGIUM (1953)
- BULGARIA (1999)
- CZECH FR (1993)
- DENMARK (1953)
- FINLAND (1991)
- FRANCE (1953)
- GERMANY (1953)
- GREECE (1953)
- HUNGARY (1992)
- ITALY (1953)
- NETHERLANDS (1953)
- NORWAY (1953)
- POLAND (1991)
- PORTUGAL (1986)
- SLOVAK FR (1993)
- SPAIN (1/1961-12/1968-1/1983)
- SWEDEN (1953)
- SWITZERLAND (1953)
- UNITED KINGDOM (1953)

CERN AC/DI/MM - ES36B 1999 - 15/6/99

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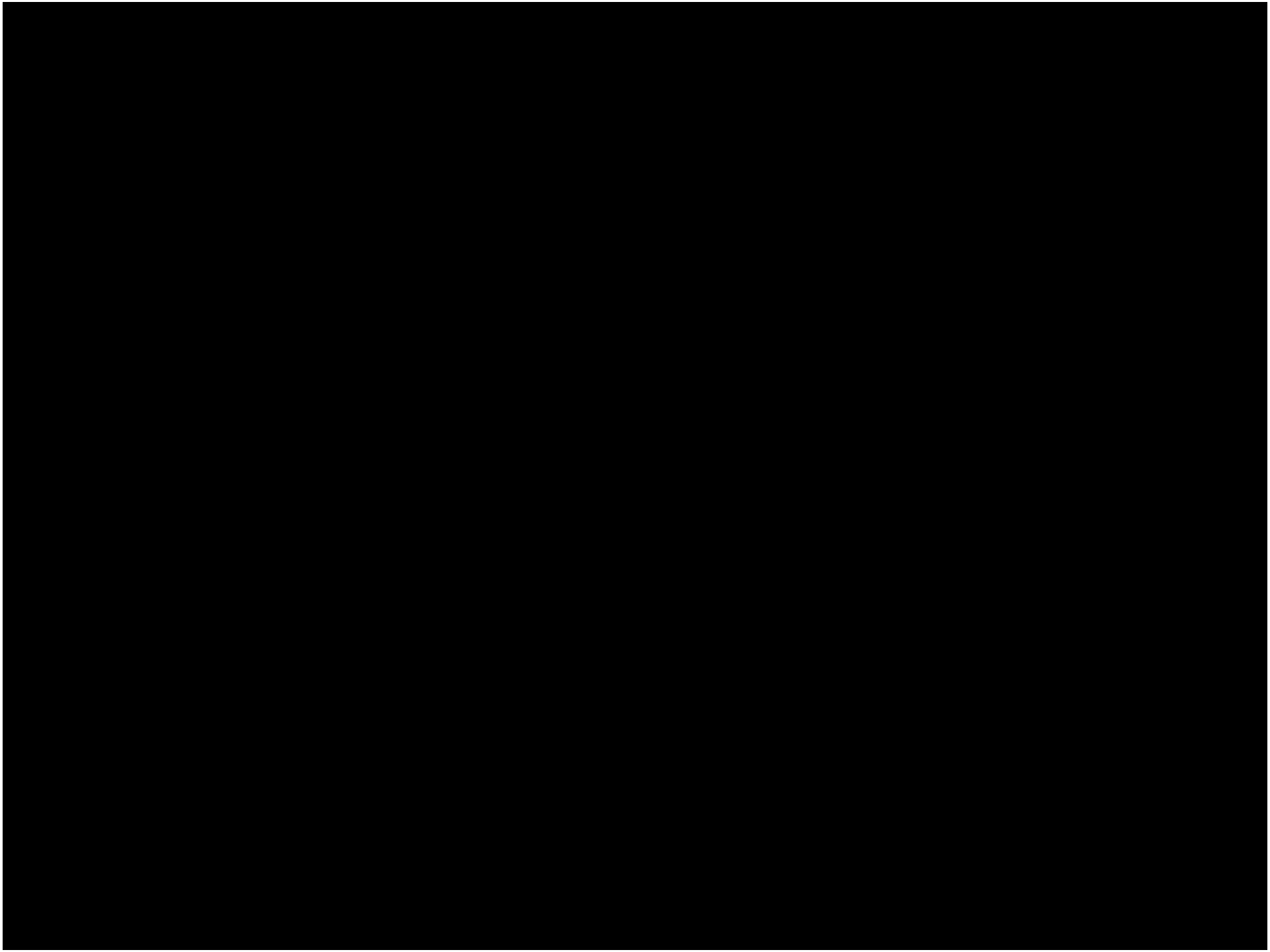
CERN