

# LHC Computing and GRID

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Развитие научных исследований, государственного управления, инновационного бизнеса, медицины, высокотехнологической промышленности требует совместной работы многих организаций по обработке большого объема данных в короткие сроки.

Для этого необходимы географически распределенные вычислительные системы, способные передавать и принимать данные порядка сотен терабайт в сутки, одновременно обрабатывать сотни тысяч задач и долговременно хранить сотни петабайт данных.

Среди технологий распределенных вычислений наибольшую популярность получили грид и облачные вычисления, цели которых одинаковы: уменьшить стоимость вычислений, увеличить надежность и гибкость, повысить масштабируемость и максимизировать удобство пользователей.

# Роль распределенной компьютерной инфраструктуры для обработки данных

- \* На семинаре 4 июля 2012 года, посвященном наблюдению бозона Хиггса, директор ЦЕРН Р.Хойер дал высокую оценку грид-технологиям и их значимости для мировой науки.
- \* Без организации грид-инфраструктуры на LHC было бы невозможно обрабатывать и хранить колоссальный объем данных, поступающих с коллайдера, и совершать научные открытия.
- \* Сегодня уже ни один крупный проект не осуществим без использования распределенной инфраструктуры для обработки данных.

# Закон Мура

## Network vs. computer performance:

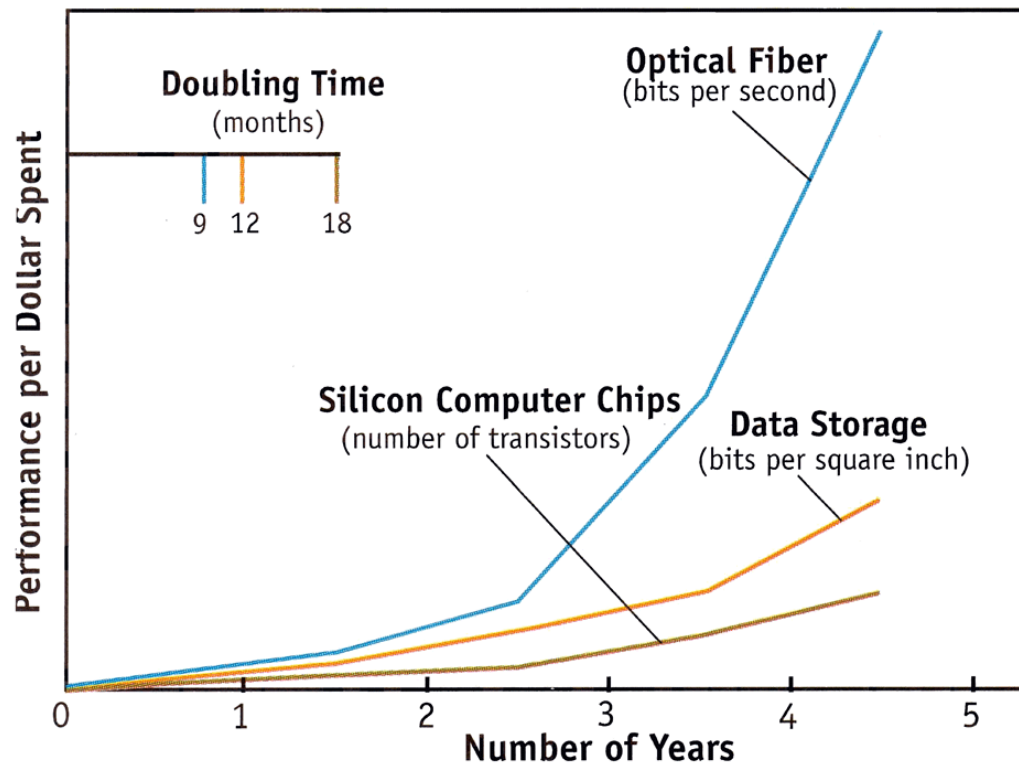
- Computer speed doubles every 18 months
- Network speed doubles every 9 months

## 1986 to 2000:

- Computers: 500 times faster
- Networks: 34000 times faster

## 2001 to 2010 (projected):

- Computers: 60 times faster
- Networks: 4000 times faster



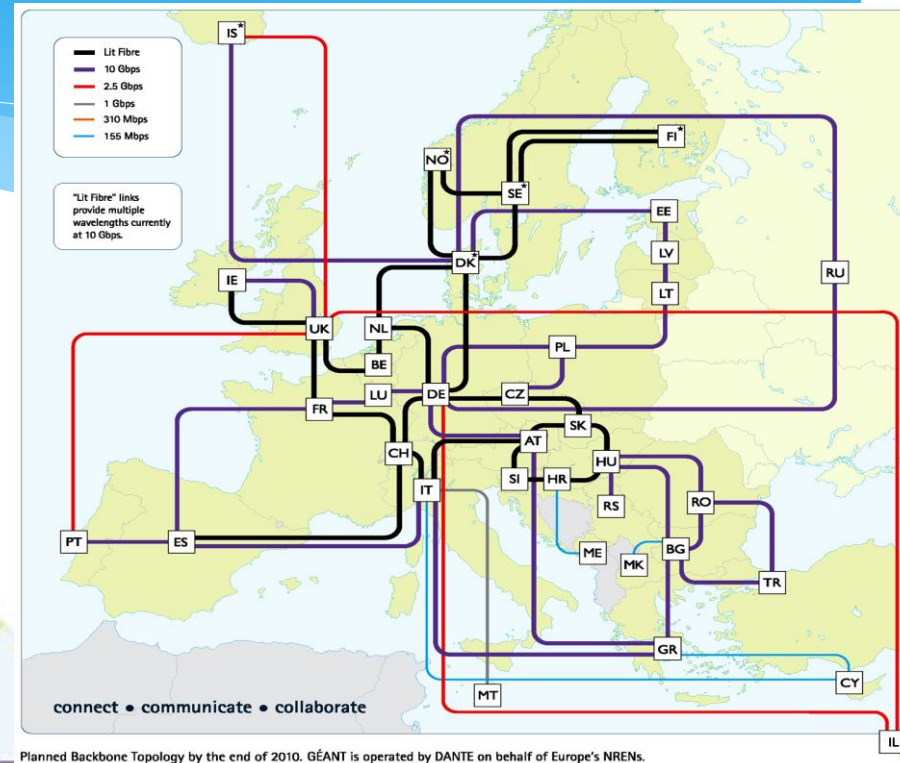
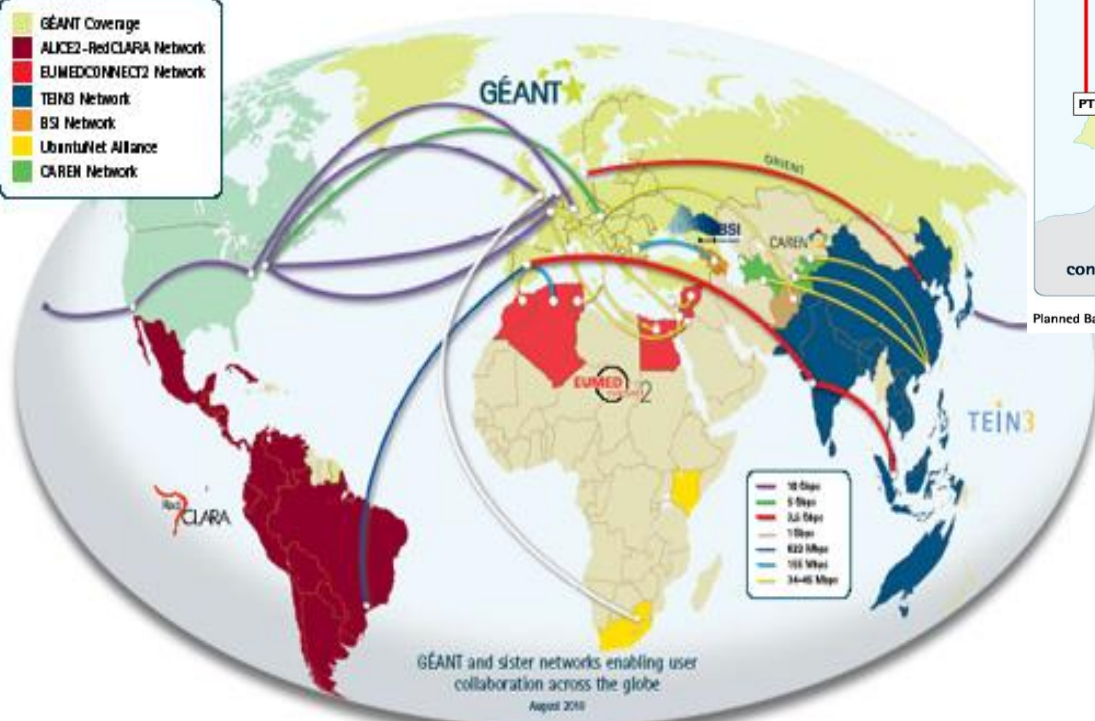
CLEO VILETT; SOURCE: VINOD KHOSLA Kleiner Perkins Caufield & Byers

# Краткая история INTERNET

- 1956 год. Основание DARPA.
- 1969 год. **Первый узел ARPANET в Лос-Анджелесе.**
- 1972 год. Изобретение электронной почты.
- 1973 год. Первые международные соединения с Англией и Норвегией.
- 1973 год. Публикация спецификации протокола TCP.
- 1982 год. TCP/IP становится стандартом Министерства обороны США.
- 1982 год. Основание European UNIX Network (EUNet).
- 1984 год. Число машин превысило 1000.
- 1986 год. Появление опорной сети NSFNet.
- 1987 год. Число машин превысило 10 000.
- 1989 год. **WWW в ЦЕРН**, машин больше 100 000, скорость 1,544 Мбит/сек.
- 1991 год. Основание Commercial Internet eXchange (CIX).
- 1992 год. Число машин 1 000 000. Первые видеоконференции.
- 1993 год. Россия (EUNet/Relcom, Demos+) входят в INTERNET.
- 1993 год. Белый Дом, ООН, Мировой Банк соединяются с INTERNET.
- 1994 год. Первый магазин принимает заказы через INTERNET. Появляются виртуальные супермаркеты, первый виртуальный сетевой банк.
- 1995 год. В России принимается программа "Создание национальной сети компьютерных телекоммуникаций для науки и высшей школы".
- 1996 год. Создание европейской опорной сети TEN-34, создание IX в Москве.
- 1997 год. Новое поколение Internet, протокол IP v.6, сеть TEN-155 в Европе
- 1998 год. **Концепция GRID** – глобальная система распределенных вычислений

# GÉANT International Connectivity

- GÉANT Coverage
- ALICE2-RedCLARA Network
- EUMEDCONNECT2 Network
- TEIN3 Network
- BSI Network
- UrbantNet Alliance
- CAREN Network



Planned Backbone Topology by the end of 2010. GÉANT is operated by DANTE on behalf of Europe's NRENs.

**WORLD INTERNET USAGE AND POPULATION STATISTICS**  
June 30, 2012

<b>World Regions</b>	<b>Population ( 2012 Est.)</b>	<b>Internet Users Dec. 31, 2000</b>	<b>Internet Users Latest Data</b>	<b>Penetration (% Population)</b>	<b>Growth 2000-2012</b>	<b>Users % of Table</b>
<a href="#"><u>Africa</u></a>	1,073,380,925	4,514,400	<b>167,335,676</b>	15.6 %	3,606.7 %	7.0 %
<a href="#"><u>Asia</u></a>	3,922,066,987	114,304,000	<b>1,076,681,059</b>	27.5 %	841.9 %	44.8 %
<a href="#"><u>Europe</u></a>	820,918,446	105,096,093	<b>518,512,109</b>	63.2 %	393.4 %	21.5 %
<a href="#"><u>Middle East</u></a>	223,608,203	3,284,800	<b>90,000,455</b>	40.2 %	2,639.9 %	3.7 %
<a href="#"><u>North America</u></a>	348,280,154	108,096,800	<b>273,785,413</b>	78.6 %	153.3 %	11.4 %
<a href="#"><u>Latin America / Caribbean</u></a>	593,688,638	18,068,919	<b>254,915,745</b>	42.9 %	1,310.8 %	10.6 %
<a href="#"><u>Oceania / Australia</u></a>	35,903,569	7,620,480	<b>24,287,919</b>	67.6 %	218.7 %	1.0 %
<a href="#"><u>WORLD TOTAL</u></a>	<b>7,017,846,922</b>	<b>360,985,492</b>	<b>2,405,518,376</b>	<b>34.3 %</b>	<b>566.4 %</b>	<b>100.0 %</b>

[\*\*http://www.internetworldstats.com\*\*](http://www.internetworldstats.com)

# R U S S I A (Russian Federation)

RU - 138,739,892 population (2011)

61,472,011 Internet users as of Dec.31, 2011, 44.3% penetration, per ITU.

5,237,420 Facebook users on Dec 31/11, 3.8% penetration rate.

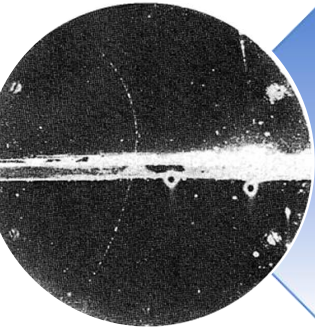


YEAR	Users	Population	% Pop.
2000	3,100,000	145,149,035	2.1 %
2007	29,400,000	141,377,752	20.8 %
2008	38,000,000	140,702,094	27.0 %
2009	45,250,000	140,041,247	32.3 %
2010	59,700,000	139,390,205	42.8 %

Марк Цукерберг

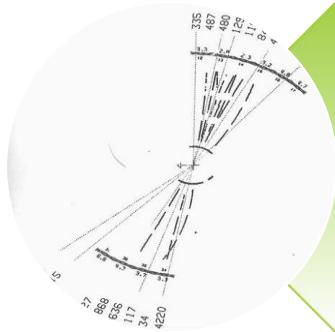


# New instruments, more data, more scientists, more computers



## A discovery in 1930-ies

- ~2 scientists in 1 country
- pen-and-paper

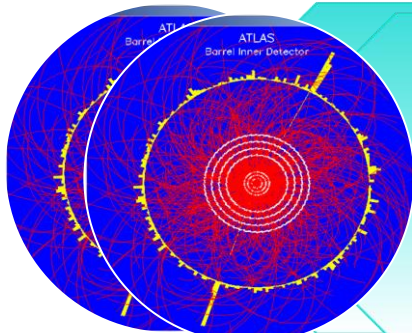
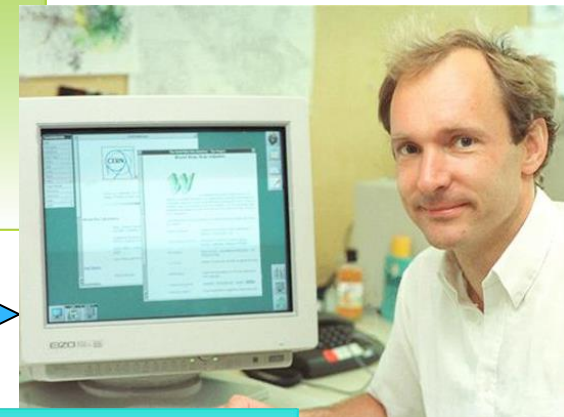


## A discovery in 1970-ies

- ~200 scientists in ~10 countries
- mainframes

1989 - WWW born in CERN

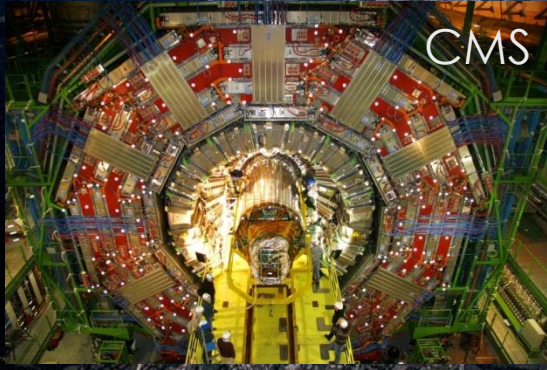
Тим Бернерс-Ли



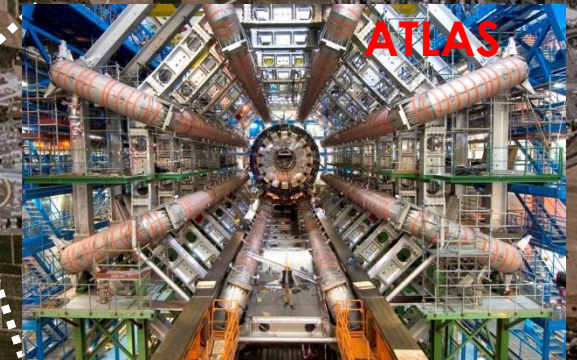
## A discovery tomorrow

- ~2000 scientists in ~100 countries
- **grids**

today



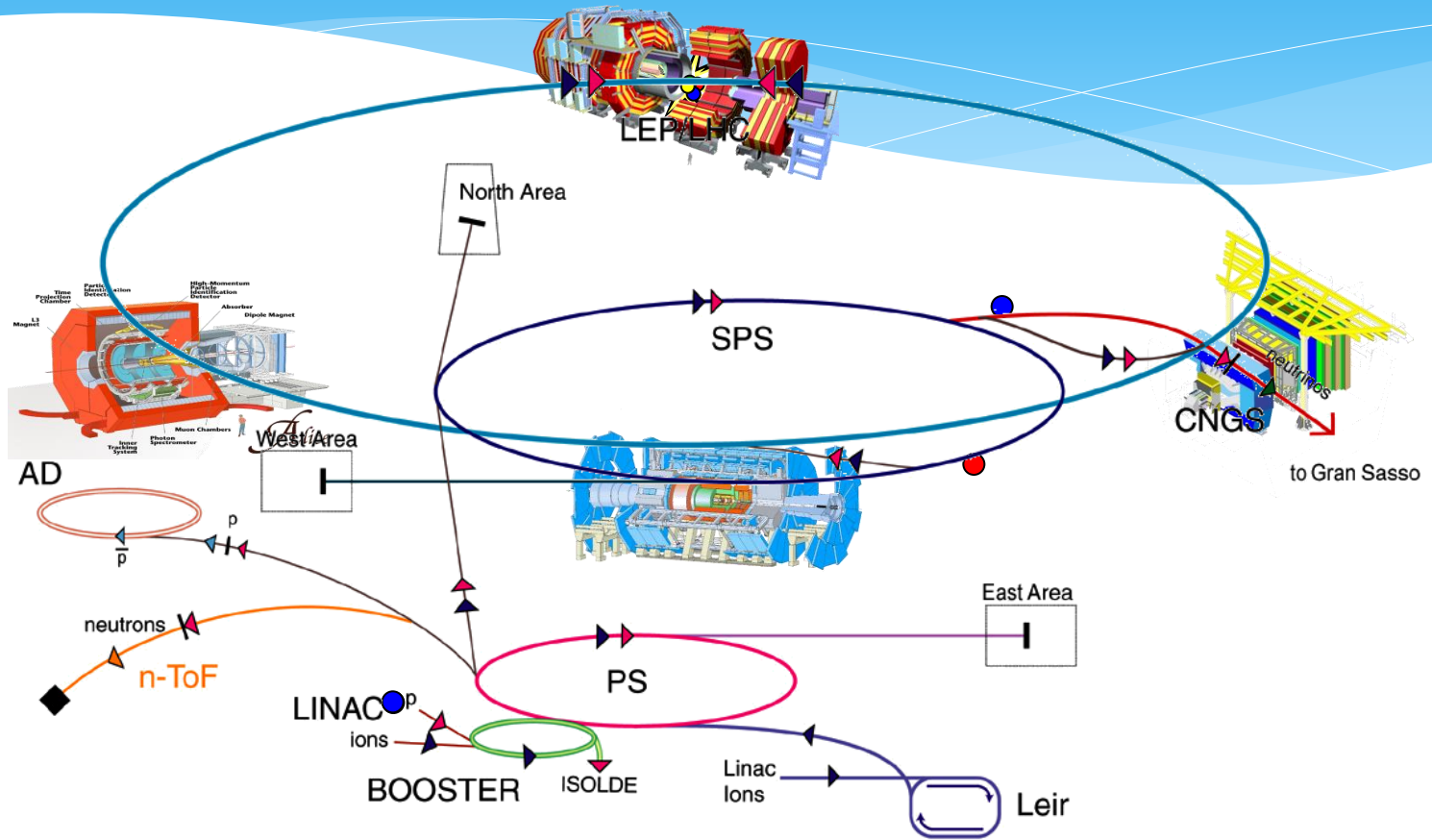
Exploration of a new energy frontier  
Proton-proton and Heavy Ion collisions  
at  $E_{CM}$  up to 14 TeV



# Large Hadron Collider

Collision of proton beams...

...observed in giant detectors



▶ p (proton)  
▶ ion  
▶ neutron

▶  $\bar{p}$  (antiproton)  
▶  $\rightarrow$  proton/antiproton conversion  
▶ neutrino

AD Antiproton Decelerator  
PS Proton Synchrotron  
SPS Super Proton Synchrotron

LHC Large Hadron Collider  
n-ToF Neutron Time of Flight  
CNGS CERN Neutrinos to Gran Sasso

# Параметры детектора АТЛАС

Энергия центра масс 14 TeV

Частота столкновений пучков  
40 MHz

Светимость :

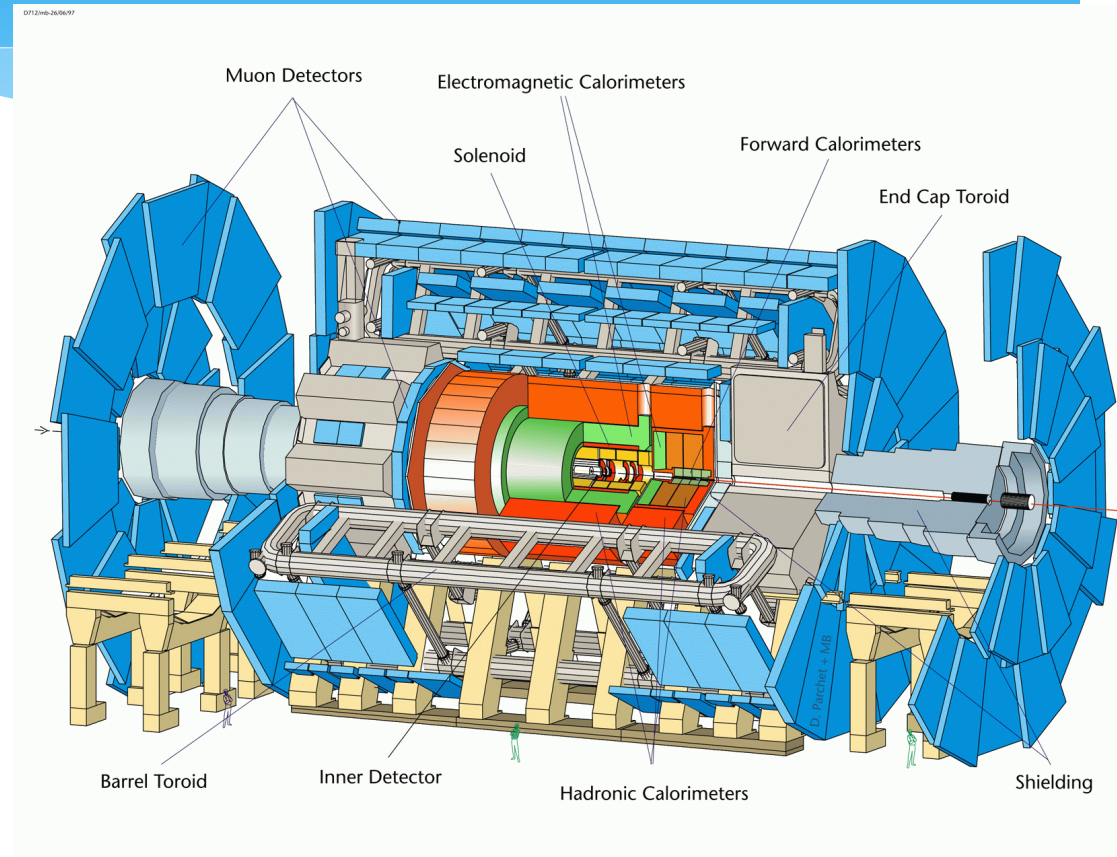
- начальная:  $10^{31} \text{ см}^{-2}\text{с}^{-1}$
- низкая:  $2 \cdot 10^{33} \text{ см}^{-2}\text{с}^{-1}$
- целевая:  $10^{34} \text{ см}^{-2}\text{с}^{-1}$

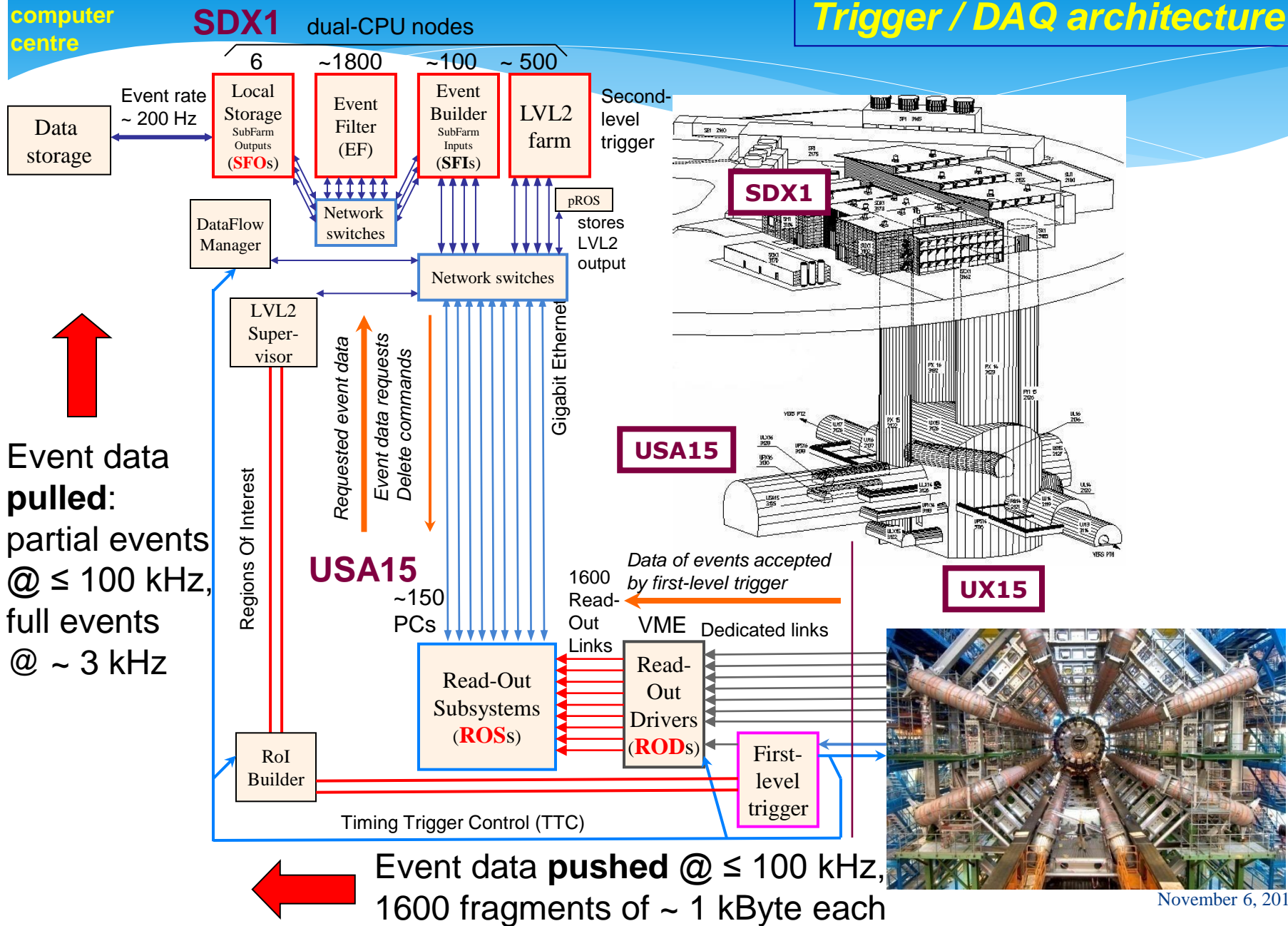
Вес 7000 тонн,

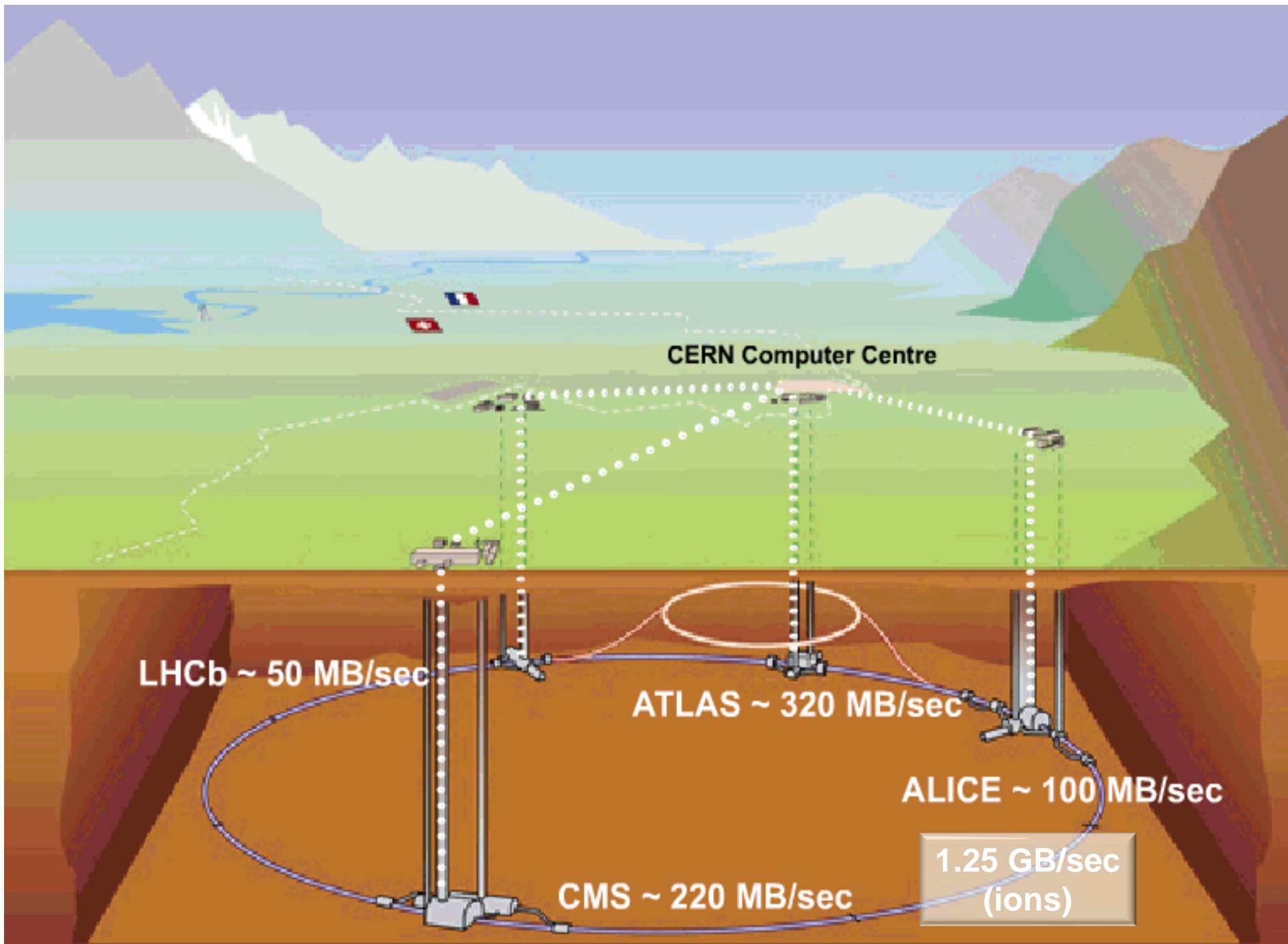
Диаметр 24м,

Длина 46м

Количество регистрирующих  
каналов 120 000 000







CERN Computer Centre

LHCb ~ 50 MB/sec

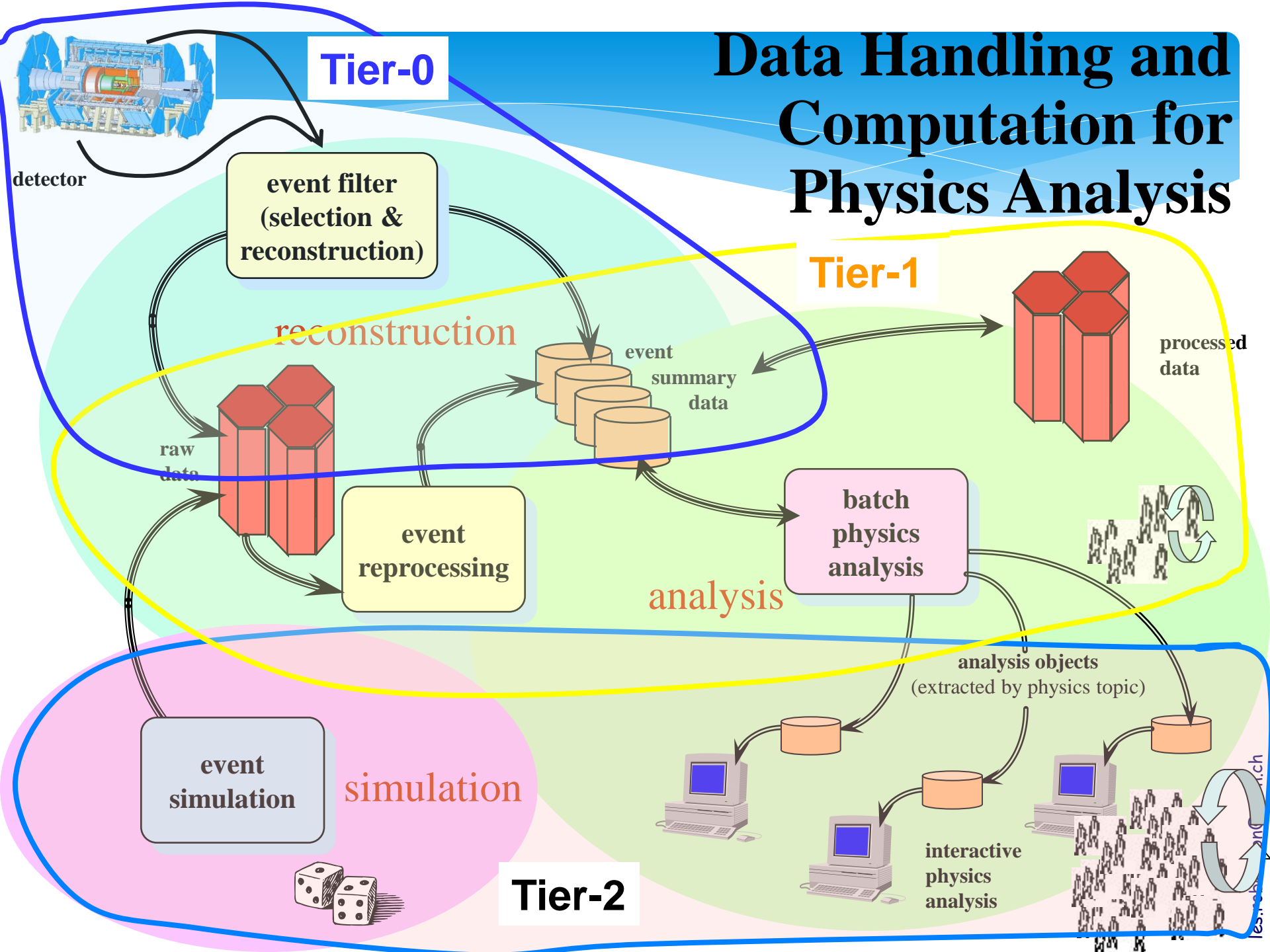
ATLAS ~ 320 MB/sec

ALICE ~ 100 MB/sec

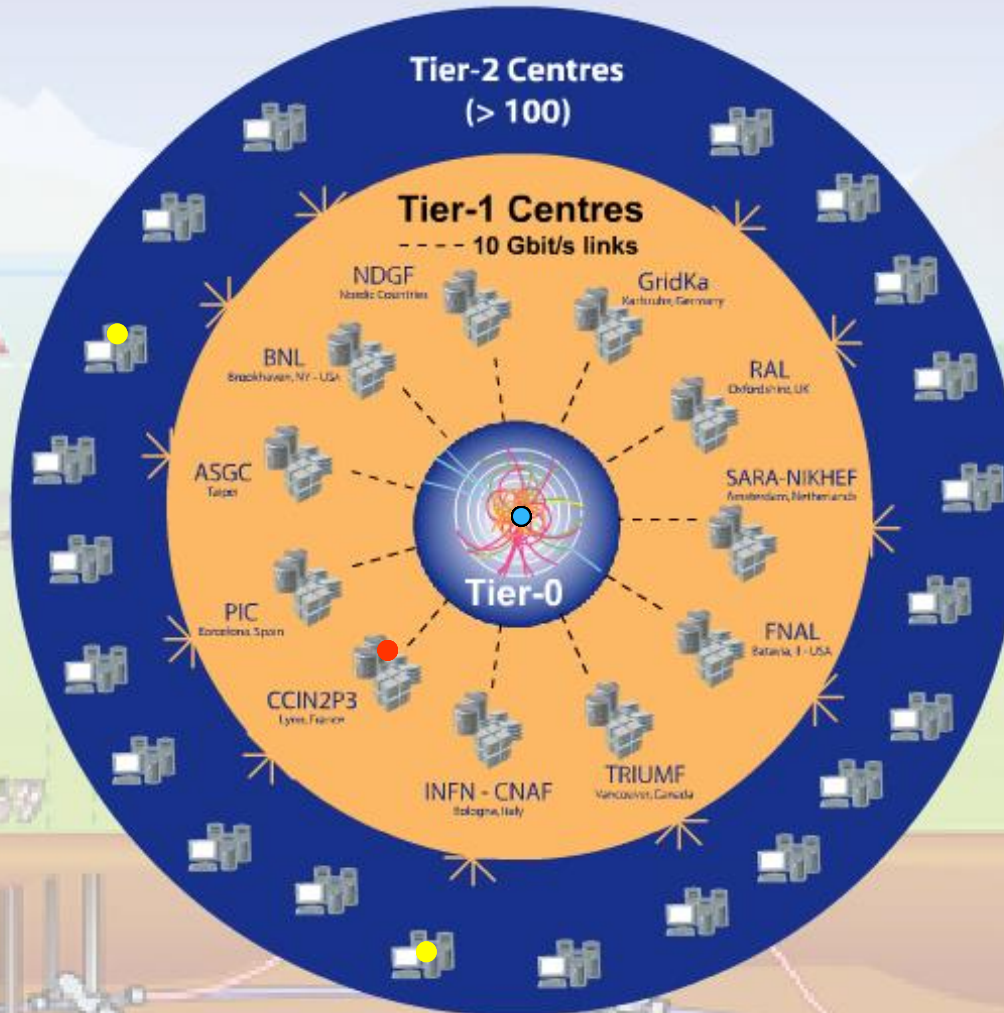
CMS ~ 220 MB/sec

1.25 GB/sec  
(ions)

# Data Handling and Computation for Physics Analysis



# Tier0 - Tier1 - Tier-2



## Tier-0 (CERN):

- accepts data from the CMS Online Data Acquisition and Trigger System
- archives RAW data
- the first pass of reconstruction and performs Prompt Calibration
- data distribution to Tier-1

## Tier-1 (11 centers):

- receives a data from the Tier-0
- data processing (re-reconstruction, skimming, calibration etc)
- distributes data and MC to the other Tier-1 and Tier-2
- secure storage and redistribution for data and MC

## Tier-2 (>200 centers):

- simulation
- user physics analysis



**Balloon (30 km)**



**Stack of disks CD with LHC data for one year**



**Concord (15 km)**



**Mont Blanc (4.8 km)**



\* **Particle Physics is a challenge of originators and developers of computing systems and software:**

- Collective character of researches that requires a free access to information;
  - Number of participants of one experiment – more than 100 persons;
  - Necessity in principle for a joint access to information in a global scale.
- *The answer to this challenge was proposed in 1989 by one of CERN researchers Tim Berners-Lee. It was a new approach to “the control over the general information about accelerators and experiments at CERN” which was the origin for the WWW development.*
- **LHC project and new challenges:**
    - Enormous data stream – almost 15 million gigabyte (which corresponds to the volume of approximately 3 million DVD) per year;
    - Number of experiment participants – more than 1000 persons;
    - Necessity in principle for a joint access to these experimental data in a global scale and their processing and analysis on the computing resources of research organizations worldwide;
    - All the data should be available after the expiration of 15 years – the expected LHC life-time.
  - The answer to the challenge was the development of a new technology of distributed computing – **GRID** which foresees a joint use of geographically distributed computing resources and data storage means.

# Концепция ГРИД

«Грид - это система, которая:

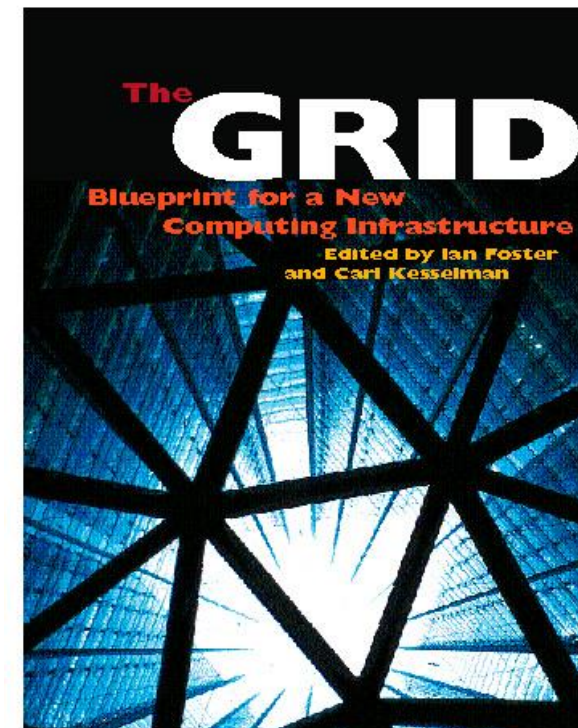
- координирует использование ресурсов при отсутствии централизованного управления этими ресурсами
- использует стандартные, открытые, универсальные протоколы и интерфейсы.
- обеспечивает высококачественное обслуживание»

(Ian Foster: "What is the grid? ", 2002 г.)

Создание компьютерной инфраструктуры нового типа, обеспечивающей глобальную интеграцию информационных и вычислительных ресурсов на основе управляющего и оптимизирующего программного обеспечения (middleware) нового поколения.

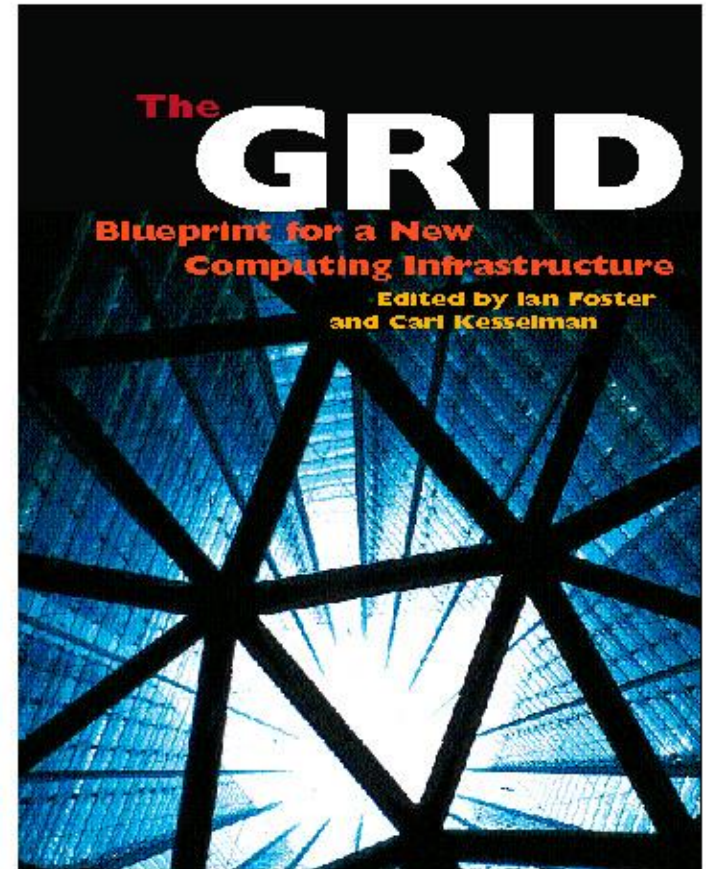
Междисциплинарный характер грид: развиваемые технологии применяются в физике высоких энергий, космофизике, микробиологии, экологии, метеорологии, различных инженерных и бизнес приложениях.

**Виртуальные организации (VO)**



# Five Emerging Models of Networked Computing From *The Grid*

- \* **Distributed Computing**
  - \* || synchronous processing
- \* **High-Throughput Computing**
  - \* || asynchronous processing
- \* **On-Demand Computing**
  - \* || dynamic resources
- \* **Data-Intensive Computing**
  - \* || databases
- \* **Collaborative Computing**
  - \* || scientists



Ian Foster and Carl Kesselman, editors, "The Grid: Blueprint for a New Computing Infrastructure," Morgan Kaufmann, 1999, <http://www.mkp.com/grids>

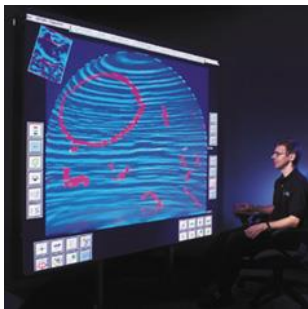
# Грид - это средство для совместного использования вычислительных мощностей и хранилищ данных посредством интернета



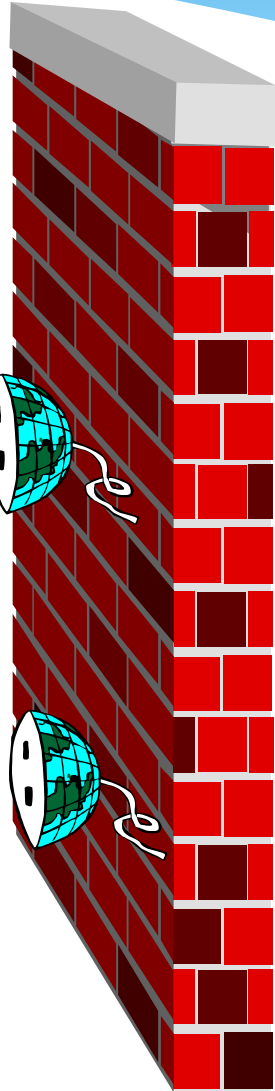
Мобильный доступ



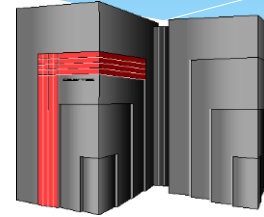
Рабочие станции



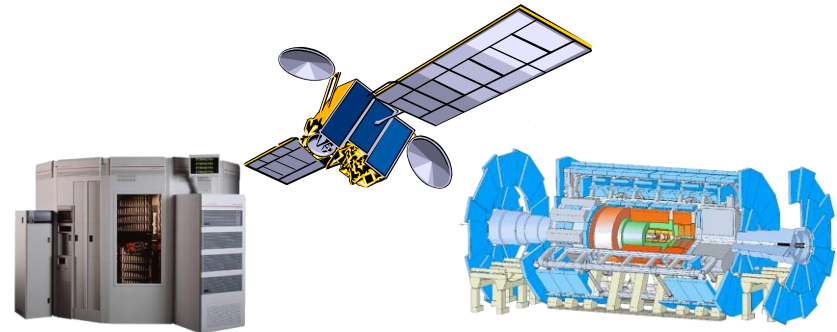
Визуализация



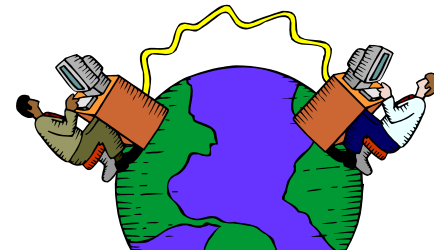
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Суперкомпьютеры, ПК- кластеры



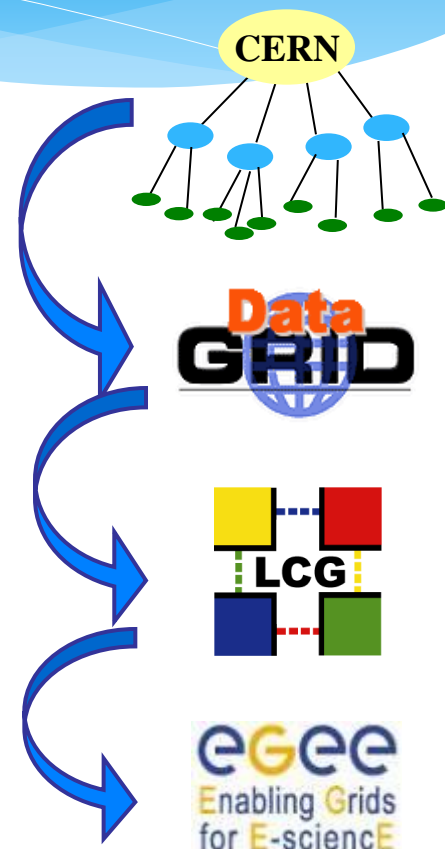
Массовая память, сенсоры, эксперименты



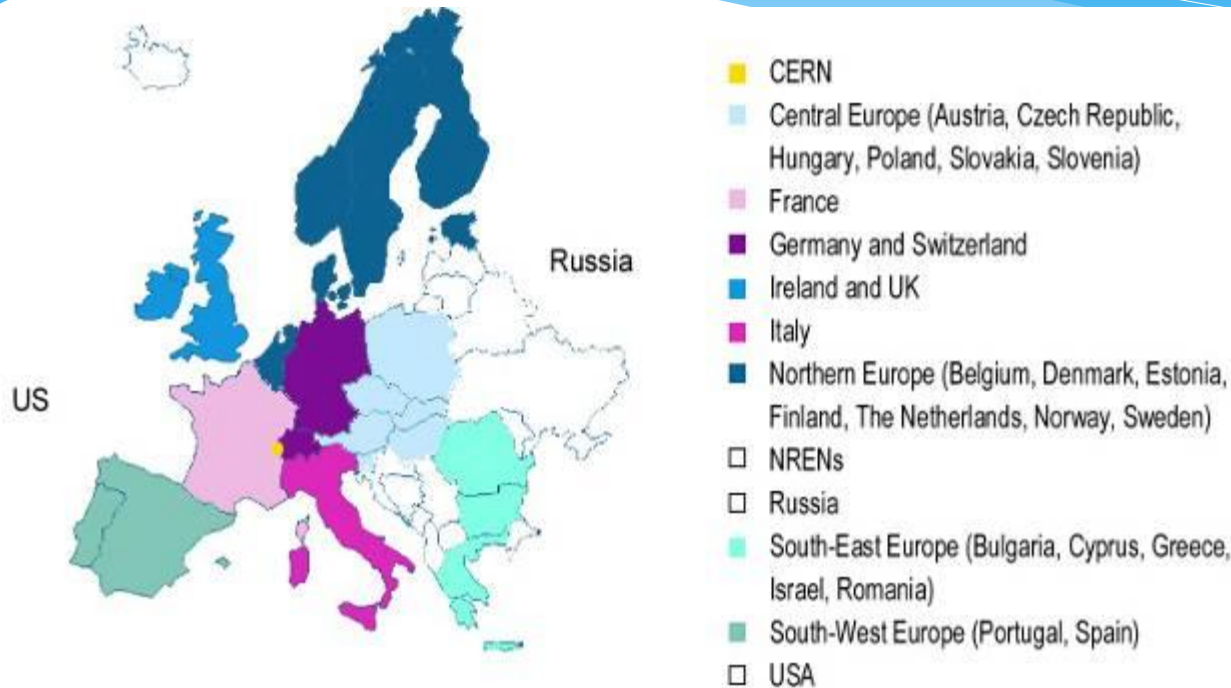
Интернет, сети

# Some history

- \* **1999 – Monarc Project**
  - \* Early discussions on how to organise distributed computing for LHC
- \* **2001-2003 - EU DataGrid project**
  - \* middleware & testbed for an operational grid
- \* **2002-2005 – LHC Computing Grid – LCG**
  - \* deploying the results of DataGrid to provide a production facility for LHC experiments
- \* **2004-2006 – EU EGEE project phase 1**
  - \* starts from the LCG grid
  - \* shared production infrastructure
  - \* expanding to other communities and sciences
- \* **2006-2008 – EU EGEE-II**
  - \* Building on phase 1
  - \* Expanding applications and communities ...
- \* **2008-2010 – EU EGEE-III**
- \* **2010-2014 - EGI-InSPIRE**



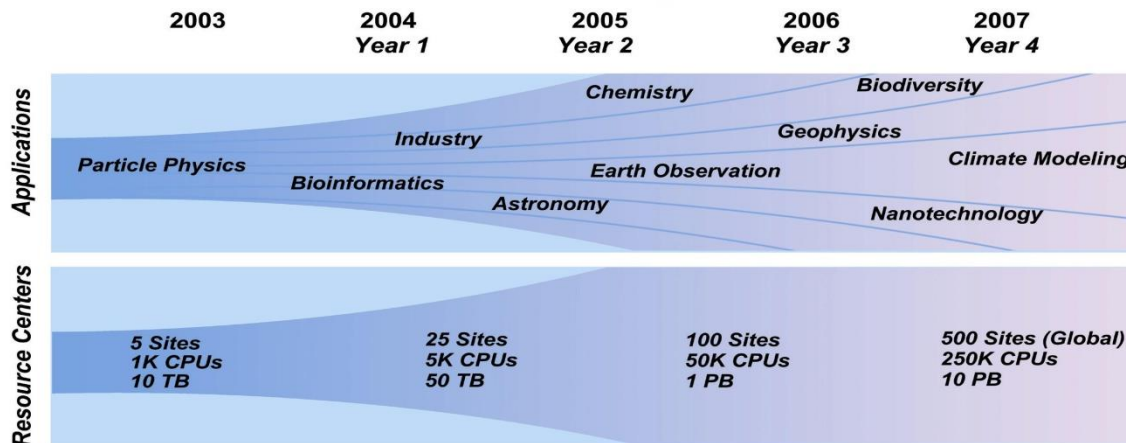
# EGEE (Enabling Grids for E-science)



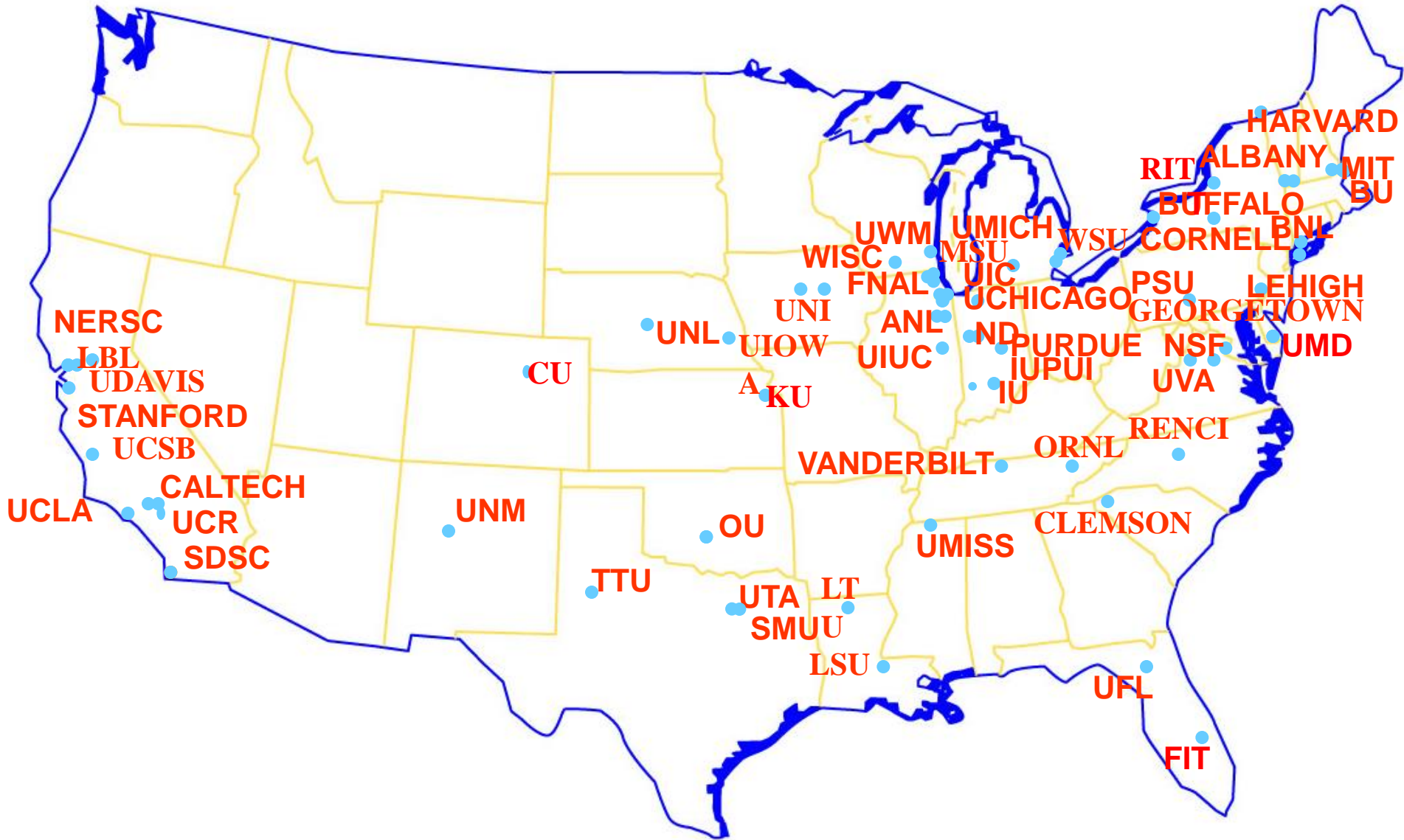
**The aim of the project is to create a global Pan-European computing infrastructure of a Grid type.**

- Integrate regional Grid efforts
- Represent leading grid activities in Europe

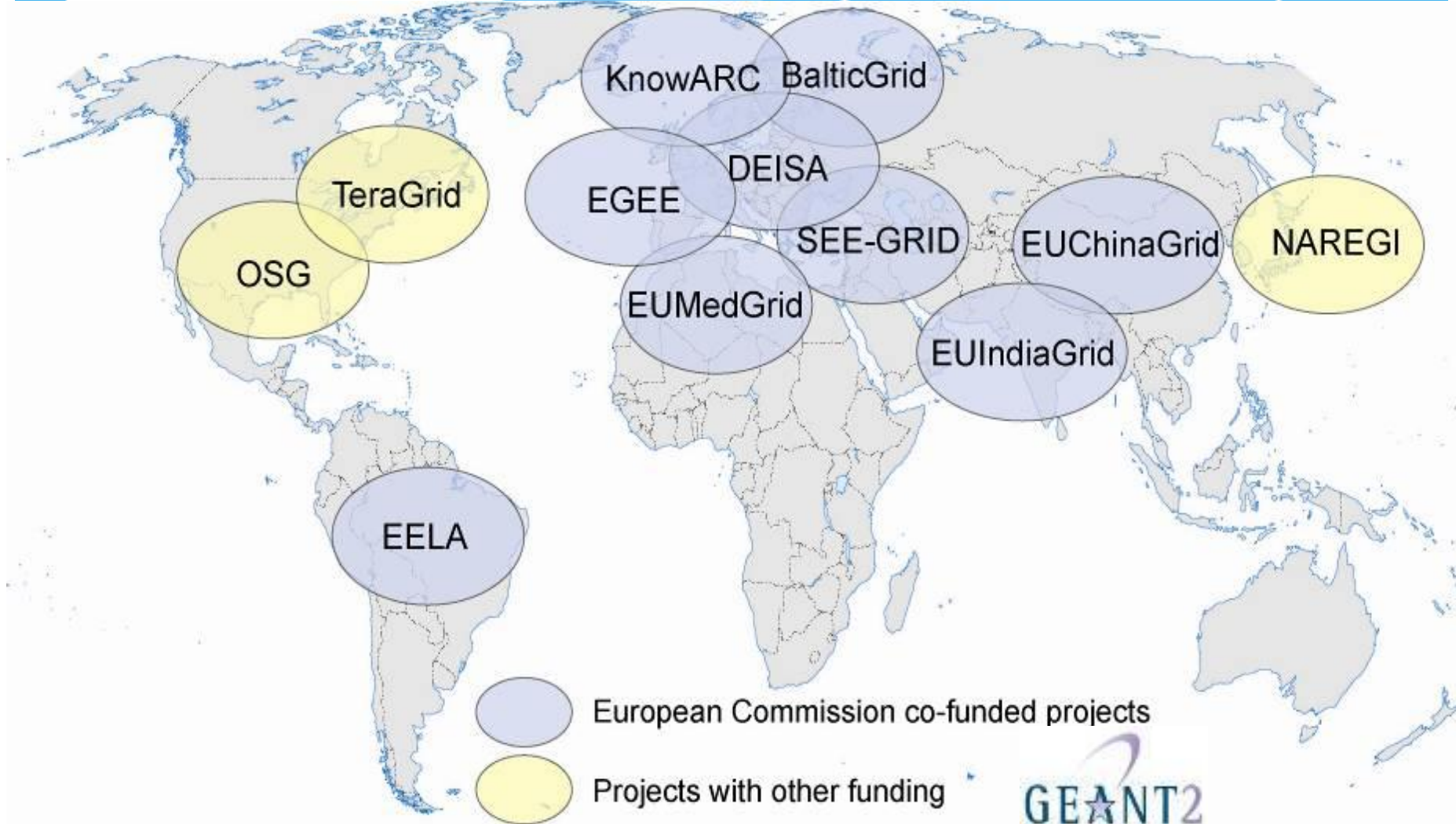
**10 Federations,  
27 Countries,  
70 Organizations**



# The Map of OSG Sites (in the US)



# Collaborating e-Infrastructures

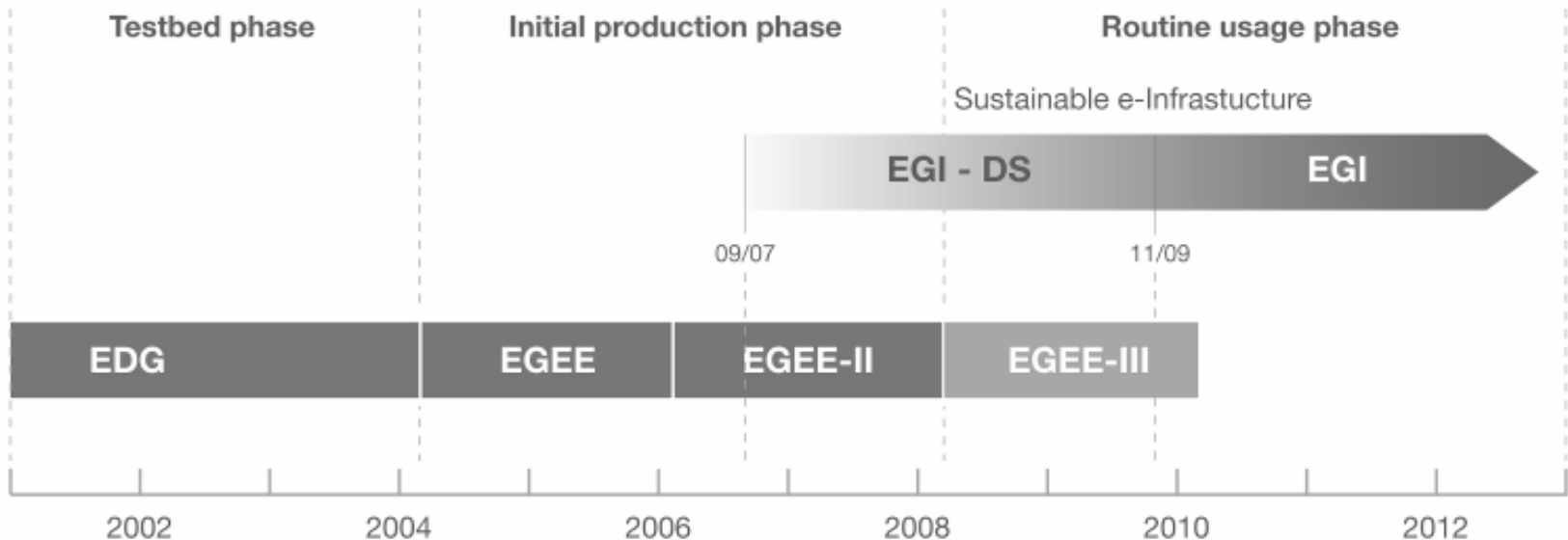


**Potential for linking ~90 countries by 2010**



# European e-Infrastructure

- Need to prepare permanent, common **Grid infrastructure**
- Ensure the long-term sustainability of the European e-infrastructure independent of short project funding cycles
- Coordinate the integration and interaction between National Grid Infrastructures (NGIs)
- Operate the European level of the production Grid infrastructure for a wide range of scientific disciplines to link NGIs



# Эволюция в ИТ

## Grid Computing

- Solving large problems with parallel computing
- Made mainstream by Globus Alliance



## Utility Computing

- Offering computing resources as a metered service
- Introduced in late 1990s



## Software as a Service

Network-based subscriptions to applications

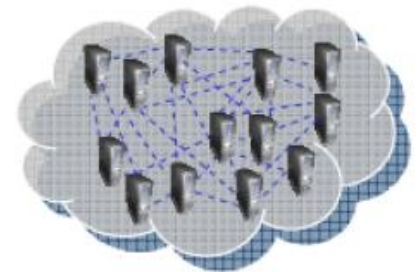
Gained momentum in 2001



## Cloud Computing

Next-Generation Internet computing

Next-Generation Data Centers



# The Future of Grids

## \* From e-Infrastructures to Knowledge Infrastructures

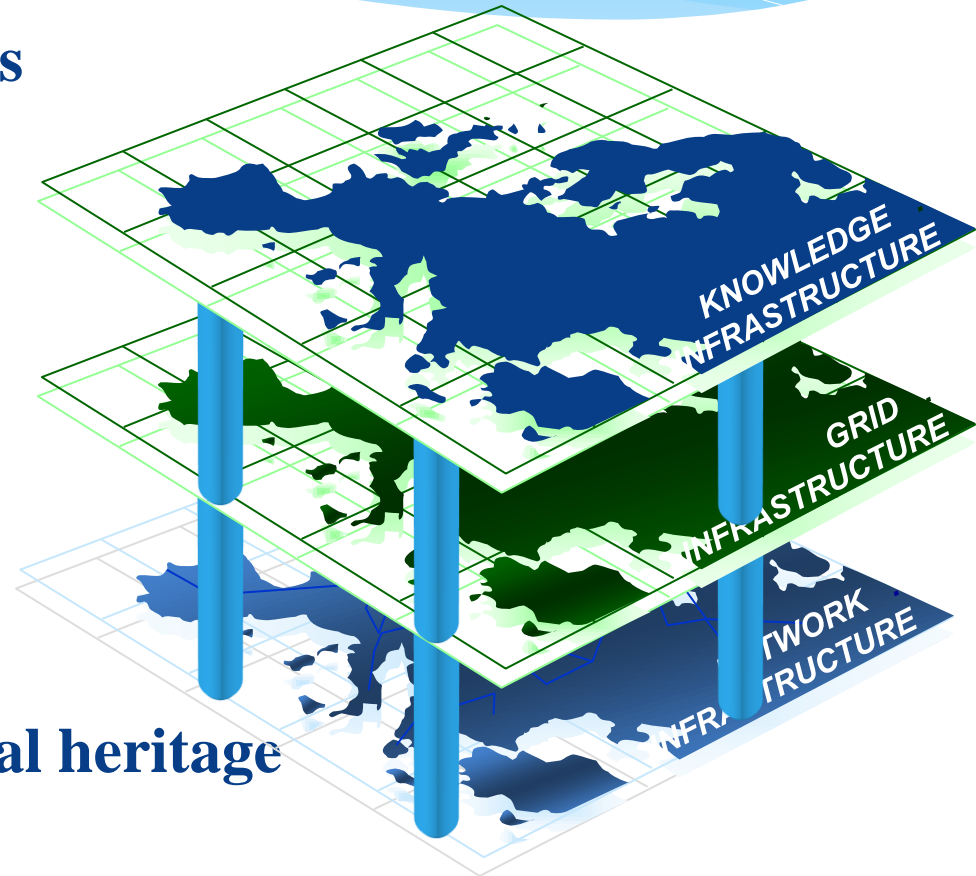
\* Network infrastructure connects computing and data resources and allows their seamless usage via Grid infrastructures

\* Federated resources and new technologies enable new application fields:

- \* Distributed digital libraries
- \* Distributed data mining
- \* Digital preservation of cultural heritage
- \* Data curation

→ Knowledge Infrastructure

Major Opportunity for Academic and Businesses alike







# EGI Capacity building 2004-2013

2004

2013

Sites 2004		Metrics March 2013		Value
CERN	1	<b>Capacity</b>	CPU cores (EGI and integrated resource providers)	372,612 (315 resource centres)
NGI_NL	2		Disk/Tape (PB)	180/167
Sweden	2		Countries	56
NGI_BG	1			
Canada	1	<b>Jobs</b>	Average Job/day (Million)	1.67 (2.25 including local computation)
NGI_FR	1			
NGI_DE	3	<b>% of total norm. CPU wall time consumed</b>	High-Energy Physics	93.78%
Russia	1		Astronomy and Astrophysics	2.78 %
NGI_UK	1		Life Sciences	1.31%
NGI_GR	1		Remaining disciplines	2.13%
NGI_FI	1	<b>CPU wall time</b>	Integrated, Billion hours Jan 2004-Mar 2013	4.8
<b>Taiwan</b>	<b>1</b>			<b>36.8 (normalized HEP-SPC06)</b>

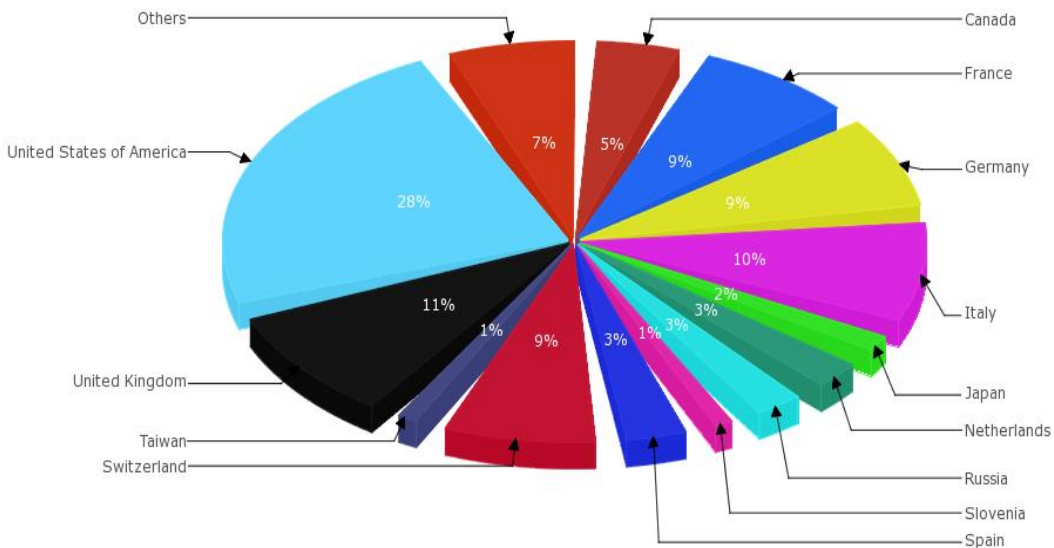


# Country Normalized CPU time (2013)

CA 'EGT View' : / normcpu-HEPSPC06 / 2012:12-2013:11 / COUNTRY-VO / lhc (x) / GRBAR-LIN / 1

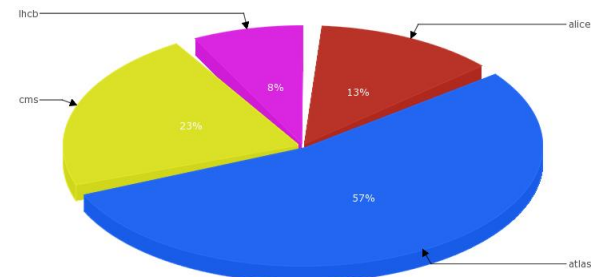
2013-11-02 21:34

COUNTRY Normalised CPU time (HEPSPC06) per COUNTRY



Developed by CERN 'EGT View' : / normcpu-HEPSPC06 / 2012:12-2013:11 / COUNTRY-VO / lhc (x) / GRBAR-LIN / 1

COUNTRY Normalised CPU time (HEPSPC06) per VO



**All Country - 16,239,752,064  
Job 562,481,423**

**Russia- 429,929,868  
16,088,697**

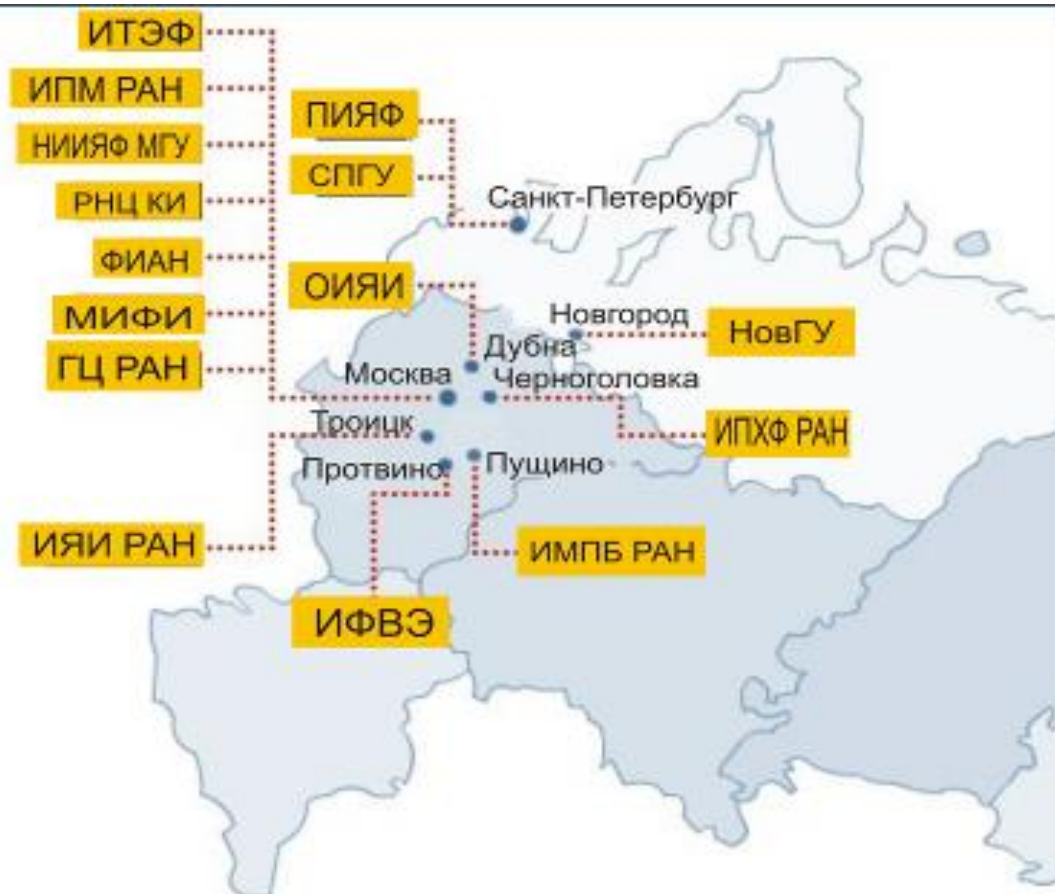
# Russian Data Intensive Grid infrastructure (RDIG)

The Russian consortium RDIG (Russian Data Intensive Grid), was set up in September 2003 as a national federation in the EGEE project.

Now the RDIG infrastructure comprises **10 Resource Centers** with **> 10000 CPU** and **> 8000 TB** of disc storage.

## *RDIG Resource Centres:*

- ITEP
- JINR-LCG2 (Dubna)
- RRC-KI
- RU-Moscow-KIAM
- RU-Phys-SPbSU
- RU-Protvino-IHEP
- RU-SPbSU
- Ru-Troitsk-ISR
- ru-IMPB-LCG2
- ru-Moscow-FIAN
- ru-Moscow-MEPHI
- ru-PNPI-LCG2 (Gatchina)
- ru-Moscow-SINP
- **Kharkov-KIPT (UA)**
- **BY-NCPHEP (Minsk)**
- **UA-KNU**
- **UA-BITP**

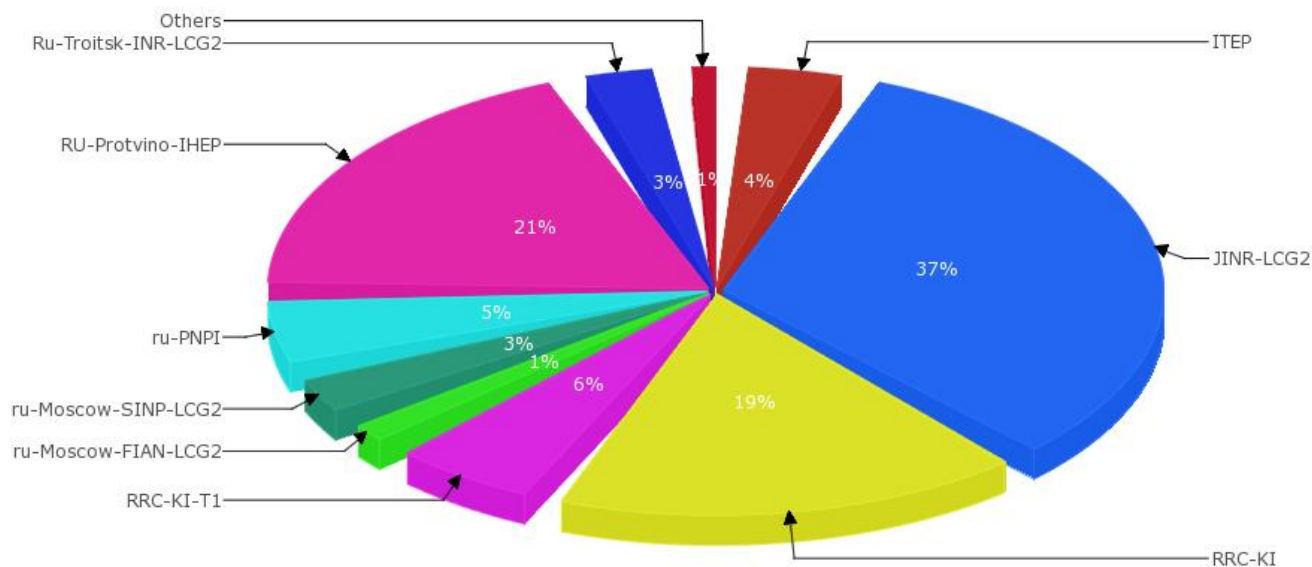


# Статистика российских центров за последние 3 года

Developed by CESGA 'EGI View': / normcpu / 2010:1-2013:11 / SITE-VO / lhc (x) / GRBAR-LIN / I

2013-11-02 21:34

Russia Normalised CPU time (kSI2K) per SITE





# Worldwide LHC Computing Grid Project (WLCG)

Основной задачей проекта WLCG является создание глобальной инфраструктуры региональных центров для обработки, хранения и анализа данных физических экспериментов LHC.

Грид-технологии являются основой построения этой инфраструктуры. *Протокол между ЦЕРН, Россией и ОИЯИ об участии в проекте LCG был подписан в 2003 году.*

*MoU об участии в проекте WLCG был подписан в 2007 году.*

Задачи российских центров и ОИЯИ в проекте WLCG в 2013 году:

- Создание комплекса тестов для gLite
- Внедрение сервисов WLCG для экспериментов
- Развитие систем мониторинга WLCG
- Система глобального мониторинга Tier3 центров
- Развитие пакетов моделирования для экспериментов
- Разработка архитектуры Tier1 центра в России

# Grids, clouds, supercomputers..

## Grids

- Collaborative environment
- Distributed resources (political/sociological)
- Commodity hardware (also supercomputers)
- (HEP) data management
- Complex interfaces (bug not feature)

## Supercomputers

- Expensive
- Low latency interconnects
- Applications peer reviewed
- Parallel/coupled applications
- Traditional interfaces (login)
- Also SC grids (DEISA, Teragrid)

Many different problems:  
Amenable to different solutions

No right answer

## Clouds

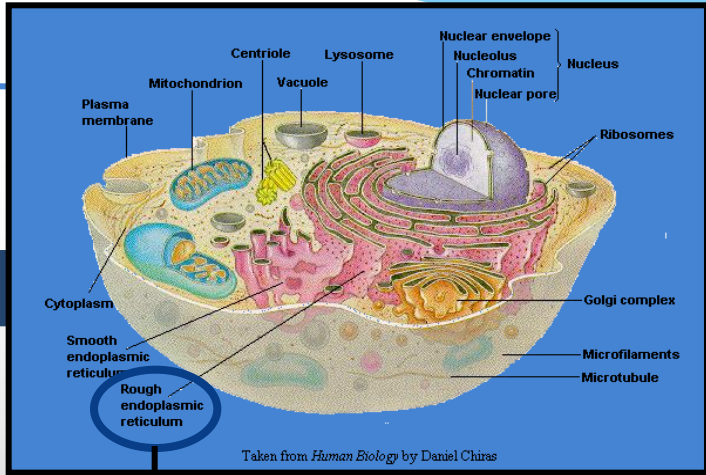
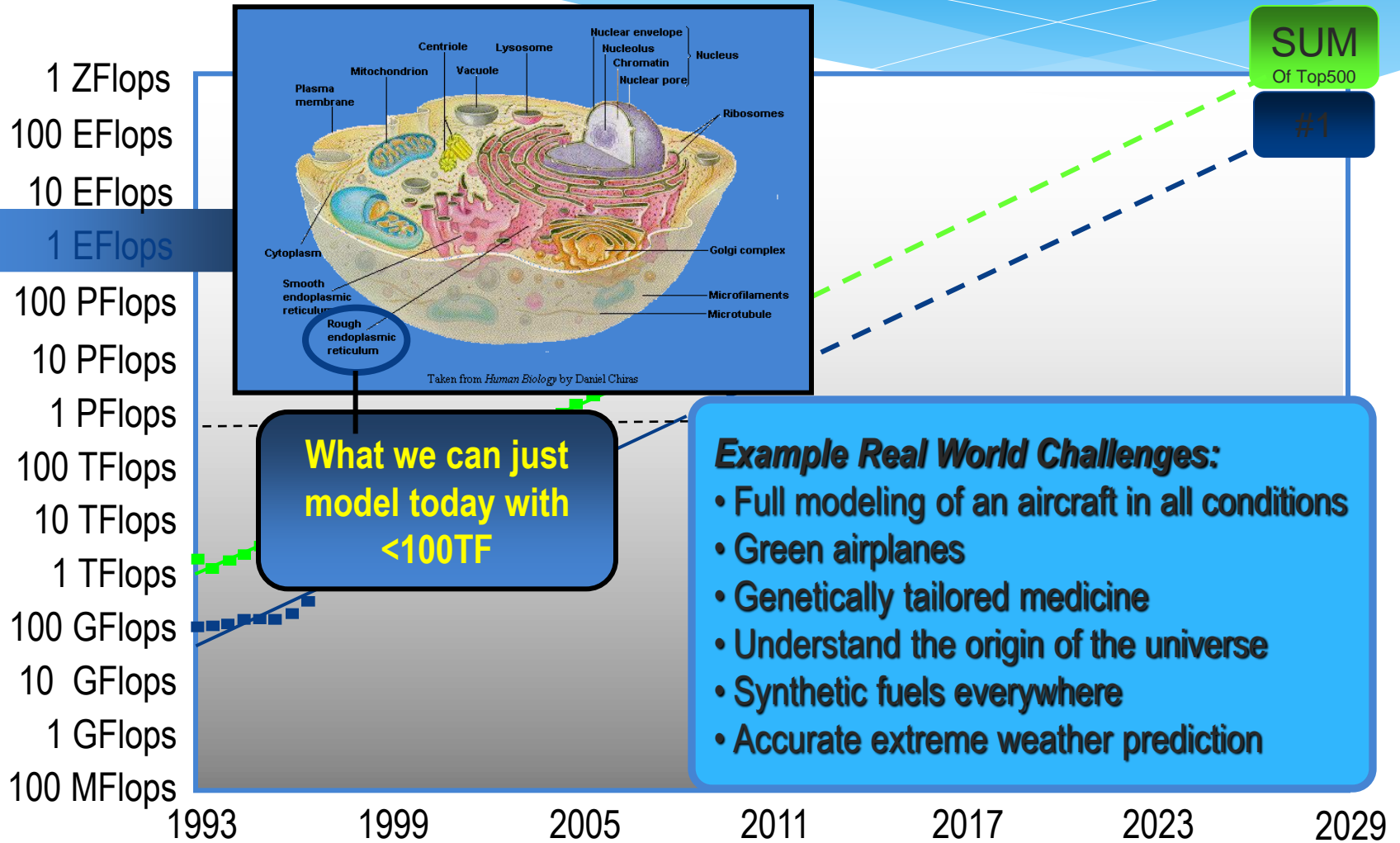
- Proprietary (implementation)
- Economies of scale in management
- Commodity hardware
- Virtualisation for service provision and encapsulating application environment
- Details of physical resources hidden
- Simple interfaces (too simple?)

## Computing

... to access millions

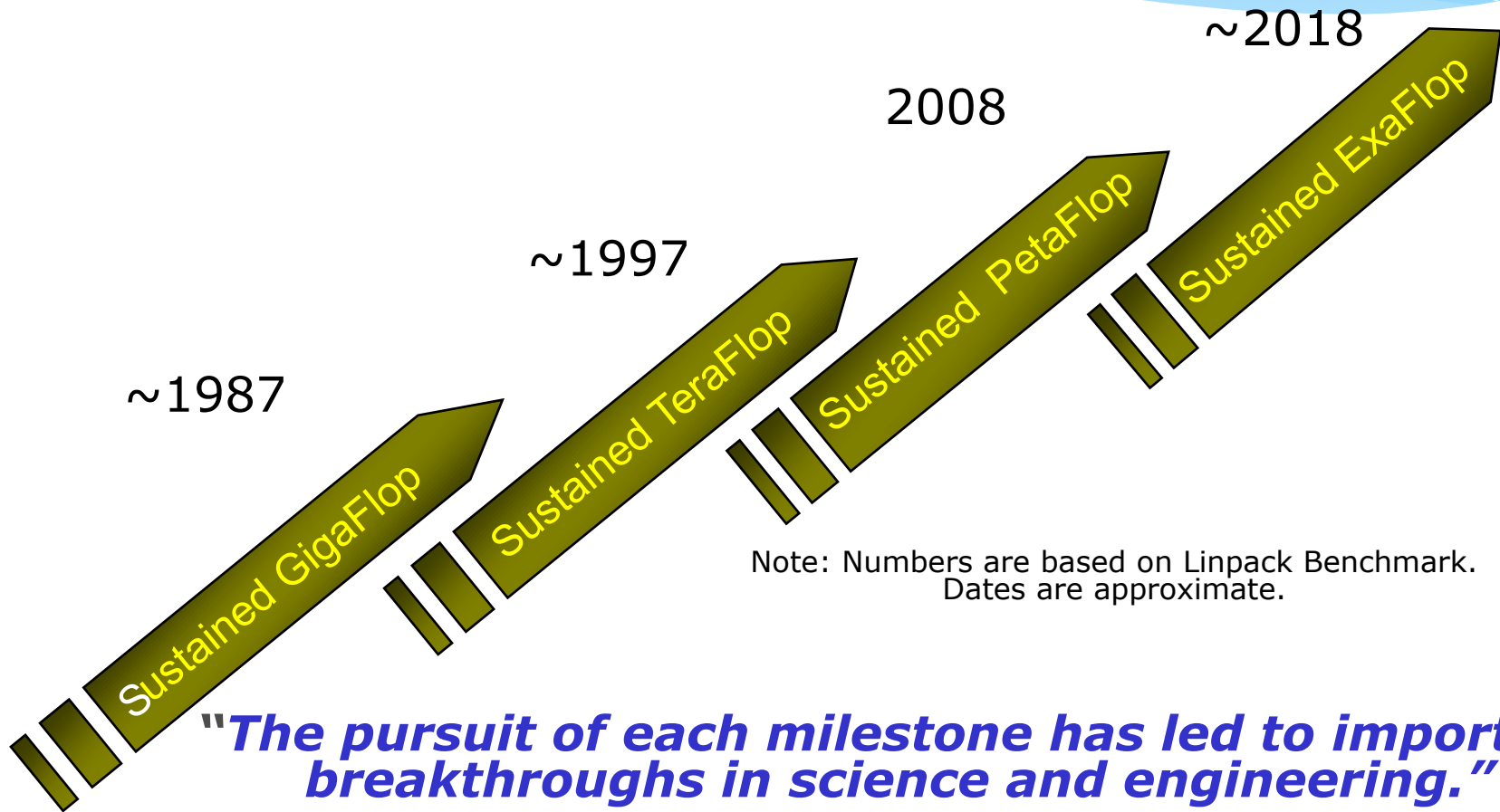
- Difficult if (much) data involved
- Control of environment → check
- Community building – people involved in Science
- Potential for huge amounts of real work

# Real World Problems Taking Us BEYOND PETASCALE



# Reach Exascale by 2018

From GigFlops to ExaFlops



Note: Numbers are based on Linpack Benchmark.  
Dates are approximate.

***"The pursuit of each milestone has led to important breakthroughs in science and engineering."***

Source: IDC "In Pursuit of Petascale Computing: Initiatives Around the World," 2007

# Top 500

Site	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
1 <a href="#">National University of Defense Technology</a> China	<a href="#">Tianhe-2 (MilkyWay-2) - TH-IVB-FEP Cluster, Intel Xeon E5-2692 12C 2.200GHz, TH Express-2, Intel Xeon Phi 31S1P</a> NUDT	3120000	33862.7	54902.4	17808
2 <a href="#">DOE/SC/Oak Ridge National Laboratory</a> United States	<a href="#">Titan - Cray XK7 , Opteron 6274 16C 2.200GHz, Cray Gemini interconnect, NVIDIA K20x</a> Cray Inc.	560640	17590.0	27112.5	8209
3 <a href="#">DOE/NNSA/LLNL</a> United States	<a href="#">Sequoia - BlueGene/Q, Power BQC 16C 1.60 GHz, Custom</a> IBM	1572864	17173.2	20132.7	7890
4 <a href="#">RIKEN Advanced Institute for Computational Science (AICS)</a> Japan	<a href="#">K computer, SPARC64 VIIIfx 2.0GHz, Tofu interconnect</a> Fujitsu	705024	10510.0	11280.4	12660
5 <a href="#">DOE/SC/Argonne National Laboratory</a> United States	<a href="#">Mira - BlueGene/Q, Power BQC 16C 1.60GHz, Custom</a> IBM	786432	8586.6	10066.3	3945
6 <a href="#">Texas Advanced Computing Center/Univ. of Texas</a> United States	<a href="#">Stampede - PowerEdge C8220, Xeon E5-2680 8C 2.700GHz, Infiniband FDR, Intel Xeon Phi SE10P</a> Dell	462462	5168.1	8520.1	4510
7 <a href="#">Forschungszentrum Juelich (FZJ)</a> Germany	<a href="#">JUQUEEN - BlueGene/Q, Power BQC 16C 1.600GHz, Custom Interconnect</a> IBM	458752	5008.9	5872.0	2301
8 <a href="#">DOE/NNSA/LLNL</a> United States	<a href="#">Vulcan - BlueGene/Q, Power BQC 16C 1.600GHz, Custom Interconnect</a> IBM	393216	4293.3	5033.2	1972
9 <a href="#">Leibniz Rechenzentrum</a> Germany	<a href="#">SuperMUC - iDataPlex DX360M4, Xeon E5-2680 8C 2.70GHz, Infiniband FDR</a> IBM	147456	2897.0	3185.1	3423
10 <a href="#">National Supercomputing Center in Tianjin</a> China	<a href="#">Tianhe-1A - NUDT YH MPP, Xeon X5670 6C 2.93 GHz, NVIDIA 2050</a> NUDT	186368	2566.0	4701.0	4040

# Концепция «Облачных вычислений»

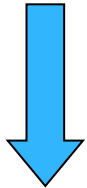
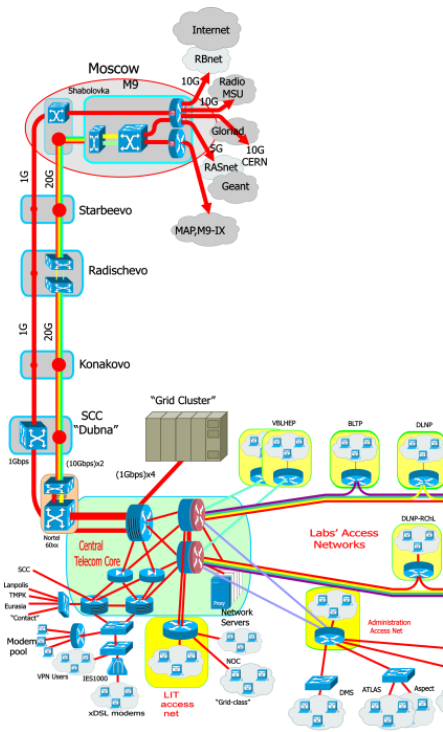
- Все есть сервис (XaaS)
  - AaaS: приложения как сервис
  - PaaS: платформа как сервис
  - SaaS: программное обеспечение как сервис
  - DaaS: данные как сервис
  - IaaS: инфраструктура как сервис
  - HaaS: оборудование как сервис
- Воплощение давней мечты о компьютерном обслуживании на уровне обычной коммунальной услуги:
  - ◇ масштабируемость
  - ◇ оплата по реальному использованию (pay-as-you-go)

# Главная цель

«ЛИТ обеспечивает полный набор ИТ-решений для ОИЯИ»

## Три основных уровня

Сетевой, ресурсный, прикладной



The JINR network infrastructure is worldwide connected through telecommunication channels:

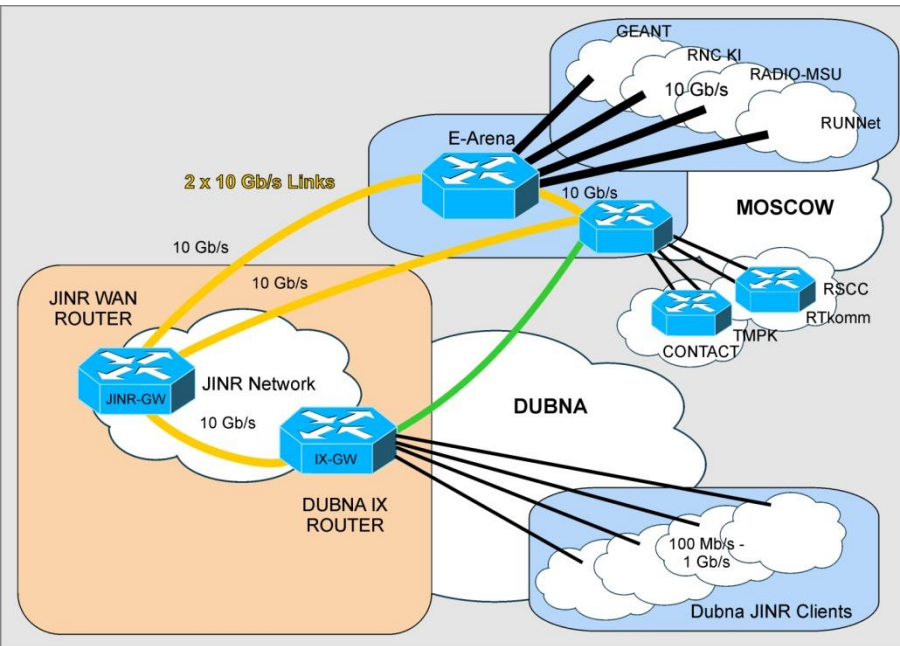
**Moscow-20Gbps**

**CERN – 10Gbps; RBnet - 10Gbps;**

**RASnet - 10Gbps; RadioMSU -**

**10Gbps; ?GEANT – 2x10Gbps?;**

**GLORIAD - 1Gbps, etc.**



## JINR Local Area Network

Comprises **7220** computers & nodes

Users – **3833**, IP – **11267**

Remote VPN users – **855**

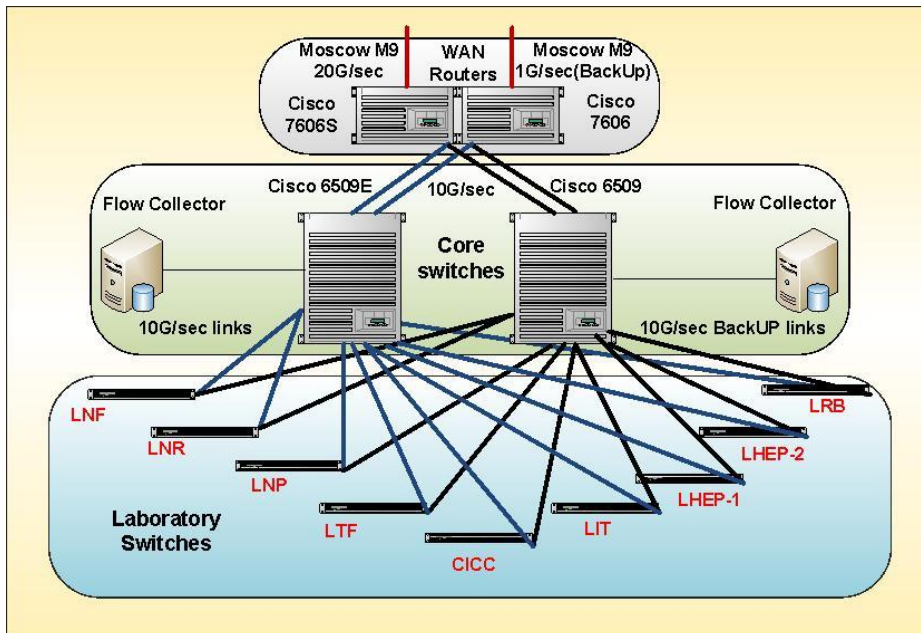
E-library- **1275**, VOIP -**107**, AFS - **365**

**High-speed transport (10 Gb/s)**

**Controlled-access** at network entrance.

**General network authorization** system involves basic services (AFS, batch systems, Grid, JINR LAN remote access, etc.)

**IPDB database** - registration and the authorization of the network elements and users, the visualization of statistics of the network traffic flow, etc.





# JINR Central Information and Computing Complex (CICC)

## JINR-LCG2 Tier2 Site



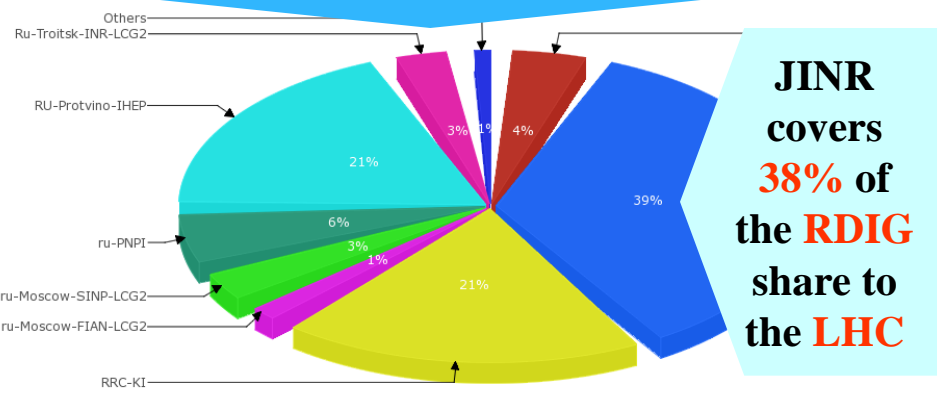
~ 18 million Jobs and 400 million normalized CPU time were executed in 2010-2013

**CICC comprises 2582 Cores**  
**Disk storage capacity 1800 TB**

Availability and Reliability = 99%

Foreseen computing resources to be allocated for JINR CICC

RDIG Normalized CPU time (HEPSPEC06) per site (2010-2013)



JINR covers 38% of the RDIG share to the LHC

	2014 – 2015	2016
CPU (HEPSPEC06)	28 000	40 000
Disk storage (TB)	4 000	8 000
Mass storage (TB)	5 000	10 000

# Remote access to ATLAS and CMS

- \* **System of remote access in real time (SRART) for monitoring and quality assessment of data from the ATLAS at JINR**
  - \* One of the most significant results of the team TDAQ ATLAS at LIT during the last few years was the participation in the development of the project TDAQ ATLAS at CERN.
- \* **JINR CMS Remote Operation Centre**
  - \* Monitoring of detector systems
  - \* Data Monitoring / Express Analysis
  - \* Shift Operations (except for run control)
  - \* Communications of JINR shifter with personal at CMS Control Room (SX5) and CMS Meyrin centre
  - \* Communications between JINR experts and CMS shifters
  - \* Coordination of data processing and data management
  - \* Training and Information





WLCG

Worldwide LHC Computing Grid

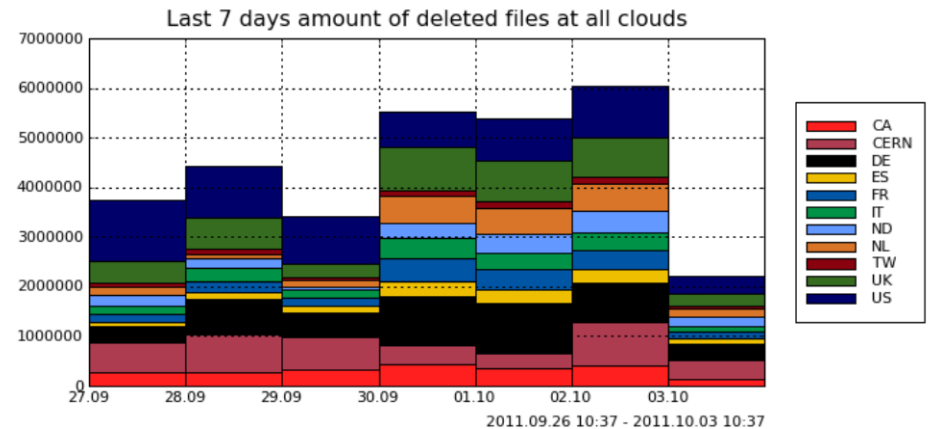
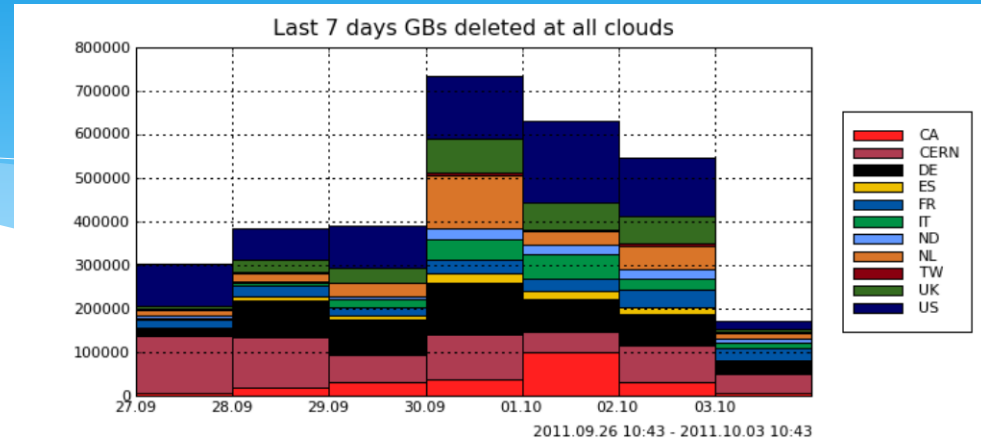
## Collaboration in the area of WLCG monitoring

- The Worldwide LCG Computing Grid (WLCG) today includes more than 170 computing centers where more than 2 million jobs are being executed daily and petabytes of data are transferred between sites.
- Monitoring of the LHC computing activities and of the health and performance of the distributed sites and services is a vital condition of the success of the LHC data processing
  - For several years CERN (IT department) and JINR collaborate in the area of the development of the applications for WLCG monitoring:
    - WLCG Transfer Dashboard
    - Monitoring of the XRootD federations
    - WLCG Google Earth Dashboard
    - Tier3 monitoring toolkit



# DDM DQ2 Deletion service

- \* The ATLAS Distributed Data Management project DQ2 is responsible for the replication, access and bookkeeping of ATLAS data across more than 120 distributed grid sites. It also enforces data management policies decided on by the collaboration and defined in the ATLAS computing model.
- \* The DQ2 Deletion Service is one of the most important DDM services. This distributed service interacts with 3rd party grid middleware and the DQ2 catalogues to serve data deletion requests on the grid. Furthermore, it also takes care of retry strategies, check-pointing transactions, load management and fault tolerance.
- \* Current version of Deletion Service was developed (and maintained) by JINR LIT specialists and is used by ATLAS Distributed Computing since autumn of 2010.



Deletion Service serves more than 120 sites. In usual operation it deletes 2-2,5M of files per day, which correspond to 400 - 500 TB per day. During the deletion campaigns when deletion was carried out on most sites, deletion rate achieved is more than 6M of files per day, reaching up to 300k files per hour.

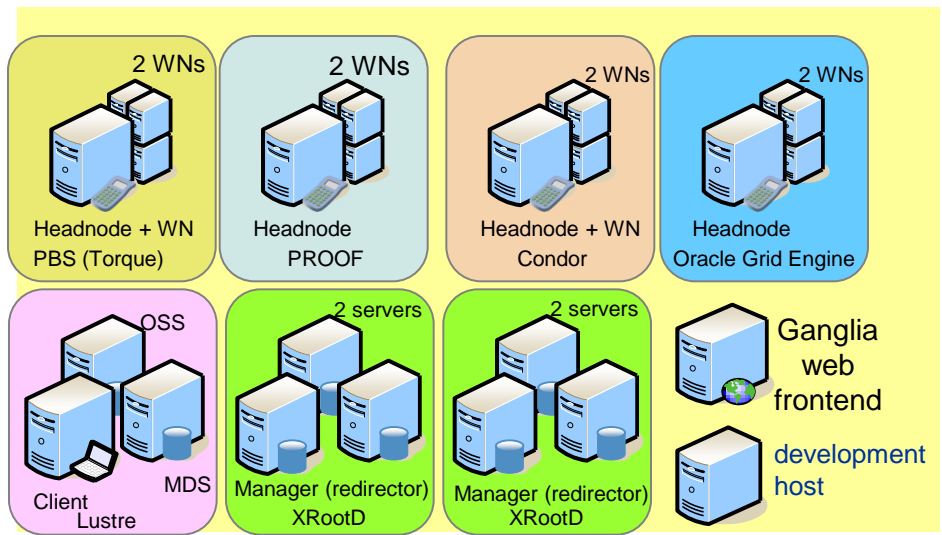
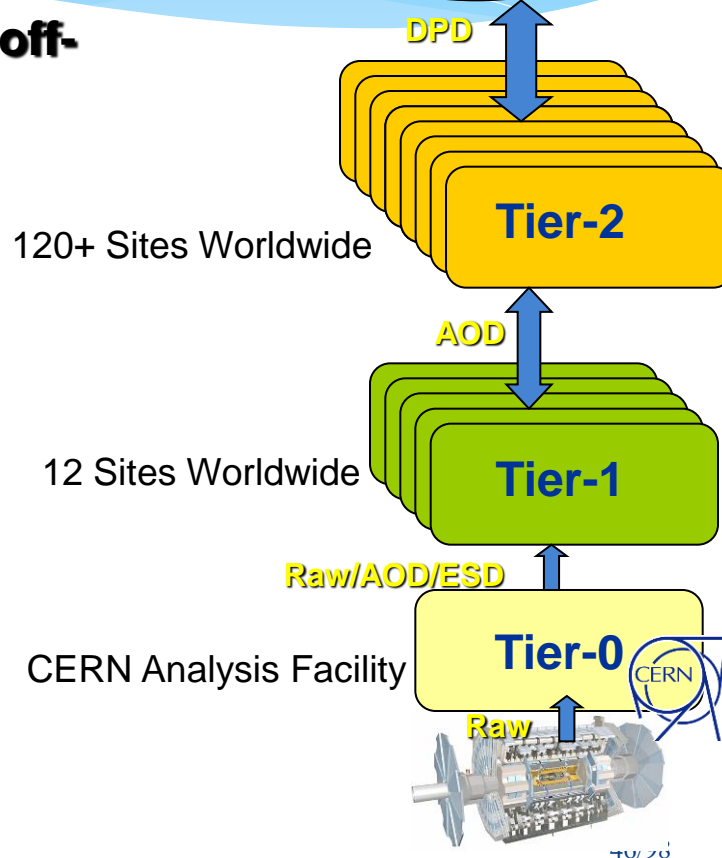
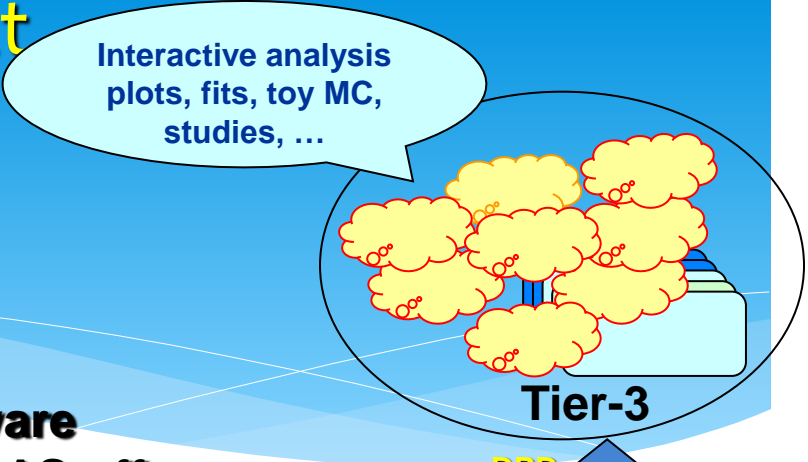
# WLCG Google Earth Dashboard

- WLCG Google Earth Dashboard is a monitoring system which allows (using Google Earth client) to visualize LHC data processing and data transfer activities on the WLCG infrastructure
- The system is widely used for dissemination purposes and demonstrates WLCG in action. The interactive display is shown at many high level presentations and public events
- WLCG Google Earth Dashboard is running at many computing centers and control rooms, including CERN, JINR, PIC, IN2P3, etc...



# Tier 3 sites monitoring project

- Traditional LHC Distributed Computing  
Tier-0 (CERN) → Tier-1 → Tier-2
- **Additional → Tier-3**
- Needs → a **global view** of the LHC computing activities
- LIT participates in the development of a software suite for **Tier-3** sites global monitoring and ATLAS off-Grid sites (Tier-3) monitoring
- A **virtual testbed** has been created at JINR which allows simulation of various Tier3 clusters and solutions for data storage



# Tier3 monitoring toolkit

- The Tier3 sites provide resources for the LHC experiments. These sites are of different sizes and with various implementation of the local resource management systems (LRMS) and mass storage system (MSS)
- The Tier3 monitoring suite, was developed on the request of the ATLAS experiment in order to satisfy the needs of Tier3 site administrators and to aggregate Tier3 monitoring information on the global experiment level
- JINR provided main effort for the development of all components of the monitoring suite, including load generator for simulation of the computing activities at the Tier3 farm.
- The testbed infrastructure had been settled up in Dubna. Using this infrastructure the monitoring toolkit was validated for various combinations of LRMS and MSS solutions along with the corresponding Ganglia and/or Nagios plugins.

✓ Along with data processing, data distribution is the key computing activity on the WLCG infrastructure.

✓ Monitoring of the data distribution is a challenging task because of the high scale of the activity and the heterogeneity of the infrastructure (various storage implementations and transport protocols used)

✓ The WLCG Transfer Dashboard developed during last two years, provides cross-experiment and cross-technology view of data transfers performed by the LHC experiments on the WLCG infrastructure

✓ JINR LIT actively participated in the development,

Namely

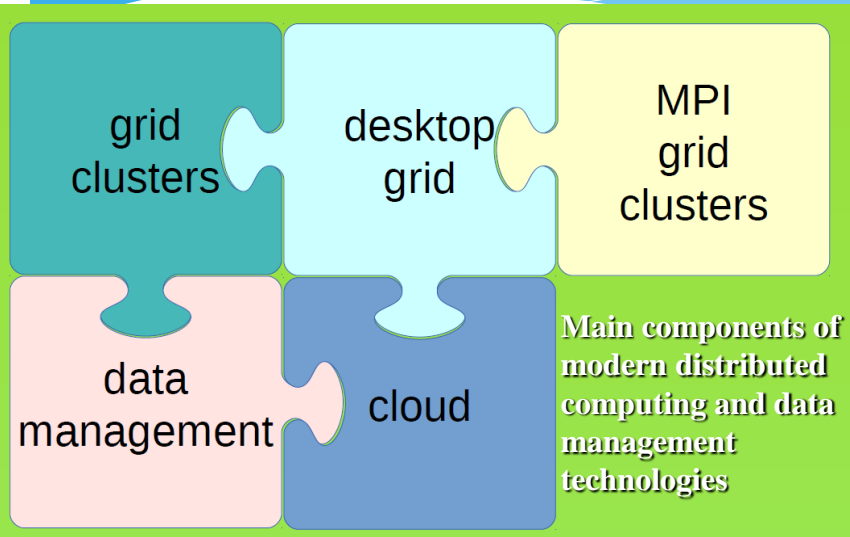
- development of the File Transfer Service (FTS) publisher to ActiveMQ,
- monitoring of the state of the FTS queues,
- integration of the traffic of the ALICE experiment which in difference with other LHC experiments does not use File Transfer Service (FTS)



WLCG home page contains the plot of the WLCG Transfer Dashboard

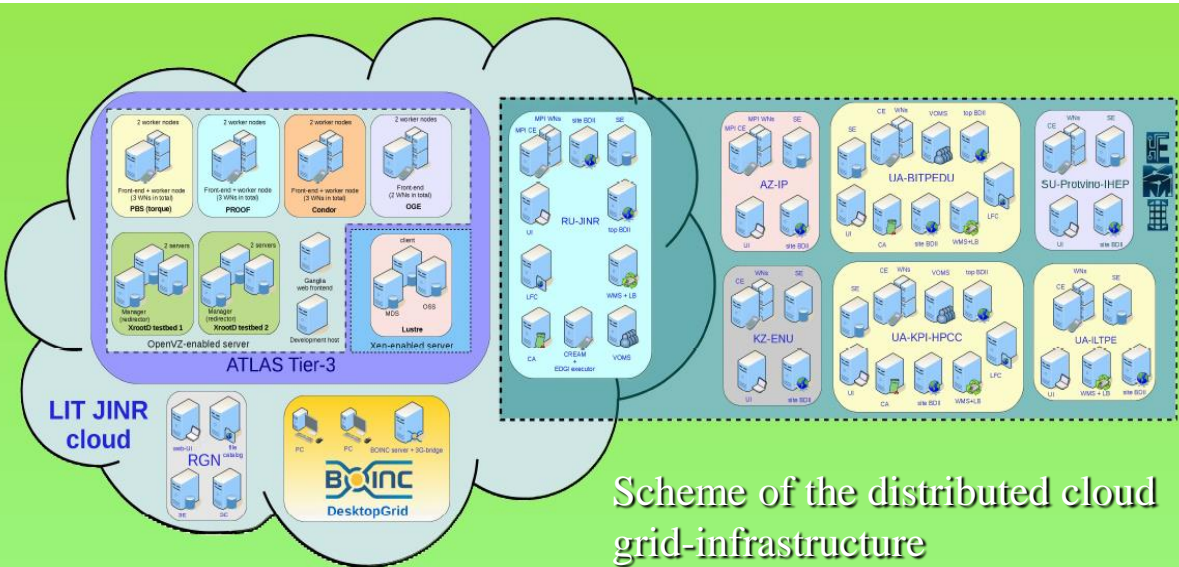


# JINR distributed cloud grid-infrastructure for training and research

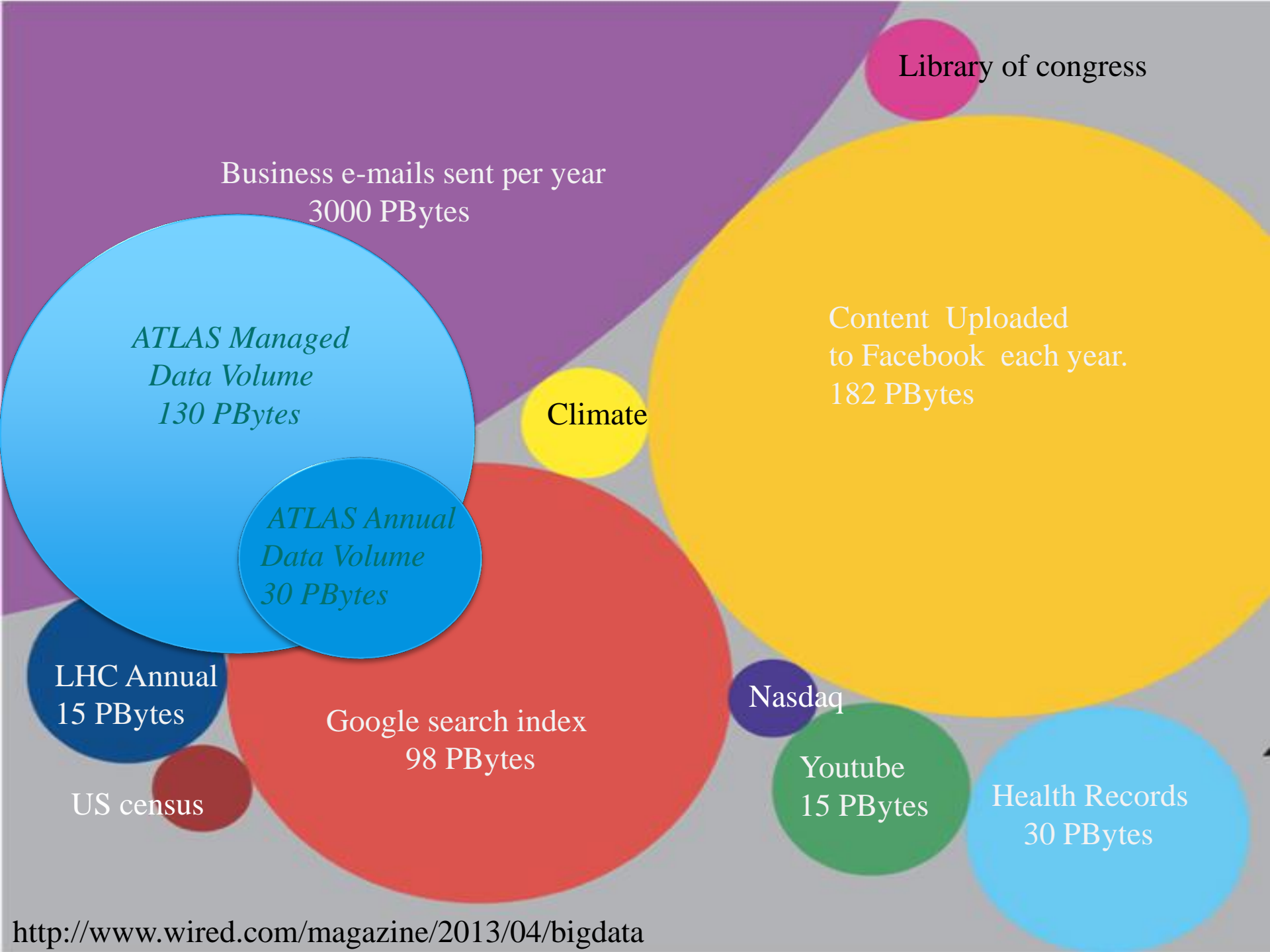


There is a demand in special infrastructure what could become a platform for training, research, development, tests and evaluation of modern technologies in distributed computing and data management. Such infrastructure was set up at LIT integrating the JINR cloud and educational grid infrastructure of the sites located at the following organizations:

- Institute of High-Energy Physics (Protvino, Moscow region),
- Bogolyubov Institute for Theoretical Physics (Kiev, Ukraine),
- National Technical University of Ukraine "Kyiv Polytechnic Institute" (Kiev, Ukraine),
- L.N. Gumilyov Eurasian National University (Astana, Kazakhstan),
- B.Verkin Institute for Low Temperature Physics and Engineering of the National Academy of Sciences of Ukraine (Kharkov, Ukraine),
- Institute of Physics of Azerbaijan National Academy of Sciences (Baku, Azerbaijan)



Scheme of the distributed cloud grid-infrastructure



Library of congress

Business e-mails sent per year  
3000 PBytes

*ATLAS Managed  
Data Volume  
130 PBytes*

Content Uploaded  
to Facebook each year.  
182 PBytes

Climate

*ATLAS Annual  
Data Volume  
30 PBytes*

LHC Annual  
15 PBytes

Google search index  
98 PBytes

Nasdaq

US census

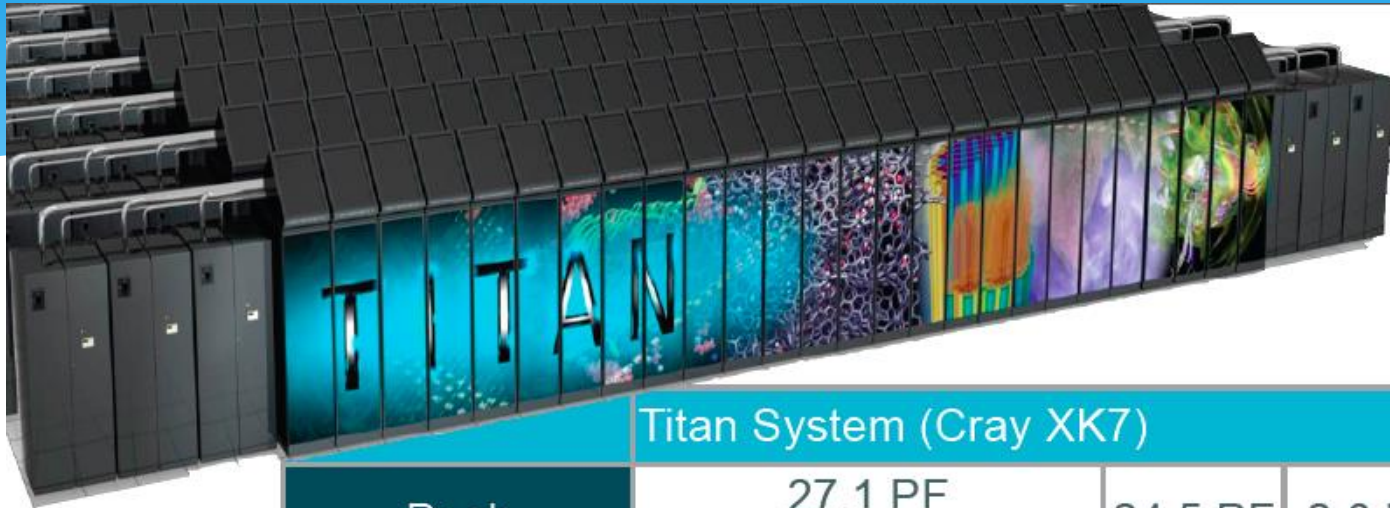
Youtube  
15 PBytes

Health Records  
30 PBytes

# Evolving PanDA for Advanced Scientific Computing

- \* Proposal titled “Next Generation Workload Management and Analysis System for BigData” – Big PanDA started in Sep 2012 (funded DoE)
  - \* Generalization of PanDA as meta application, providing location transparency of processing and data management, for HEP and other data-intensive sciences, and a wider exascale community.
- \* There are three dimensions to evolution of PanDA
  - \* Making PanDA available beyond ATLAS and High Energy Physics
  - \* Extending beyond Grid (Leadership Computing Facilities, High-Performance Computing, Google Compute Engine (GCE), Clouds, Amazon Elastic Compute Cloud (EC2), University clusters)
  - \* Integration of network as a resource in workload management

# Leadership Computing Facilities. Titan



Titan System (Cray XK7)			
Peak Performance	27.1 PF 18,688 compute nodes	24.5 PF GPU	2.6 PF CPU
System memory	710 TB total memory		
Interconnect	Gemini High Speed Interconnect	3D Torus	
Storage	Lustre Filesystem	32 PB	
Archive	High-Performance Storage System (HPSS)	29 PB	
I/O Nodes	512 Service and I/O nodes		

# Tier1 center



**March 2011 - Proposal to create the LCG Tier1 center in Russia (official letter by Minister of Science and Education of Russia A. Fursenko has been sent to CERN DG R. Heuer):**

NRC KI for ALICE, ATLAS, and LHC-B  
LIT JINR (Dubna) for the CMS experiment

**The Federal Target Programme Project: «Creation of the automated system of data processing for experiments at the LHC of Tier-1 level and maintenance of Grid services for a distributed analysis of these data»**

**Duration: 2011 – 2013**

**September 2012 – Proposal was reviewed by WLCG OB and JINR and NRC KI Tier1 sites were accepted as a new “Associate Tier1”**

**Full resources - in 2014 to meet the start of next working LHC session.**



**ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE**  
**EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH**  
Laboratoire Européen pour la Physique des Particules  
European Laboratory for Particle Physics

Mail address:  
Dr. Ian Bird  
CERN, IT Department  
CH-1211 GENEVE 23  
Switzerland  
Tel: +41 22 767 5888

E-mail : [ian.bird@cern.ch](mailto:ian.bird@cern.ch)

Votre référence/Your reference:  
Notre référence/Our reference:

Subject: Acceptance of the proposal to build Tier 1 centres in Russia

Geneva, October 12, 2012

Dear Directors,

As you know, the proposals from the National Research Centre – “Kurchatov Institute” and the Joint Institute for Nuclear Research, Dubna, to build Tier 1 centres for LHC data analysis were discussed in the recent WLCG Overview Board held on September 28. I am very happy to report that the proposals were well received by the members of the board, and that the decision was made to accept the Russian sites as a new “Associate Tier 1”. This decision will be noted in the formal minutes of the meeting.

The next step is now to proceed to signing the WLCG Memorandum of Understanding. The WLCG project office will assist in drafting this MoU, which should be signed by the relevant funding agencies for the two Russian Institutes, or their designated agents.

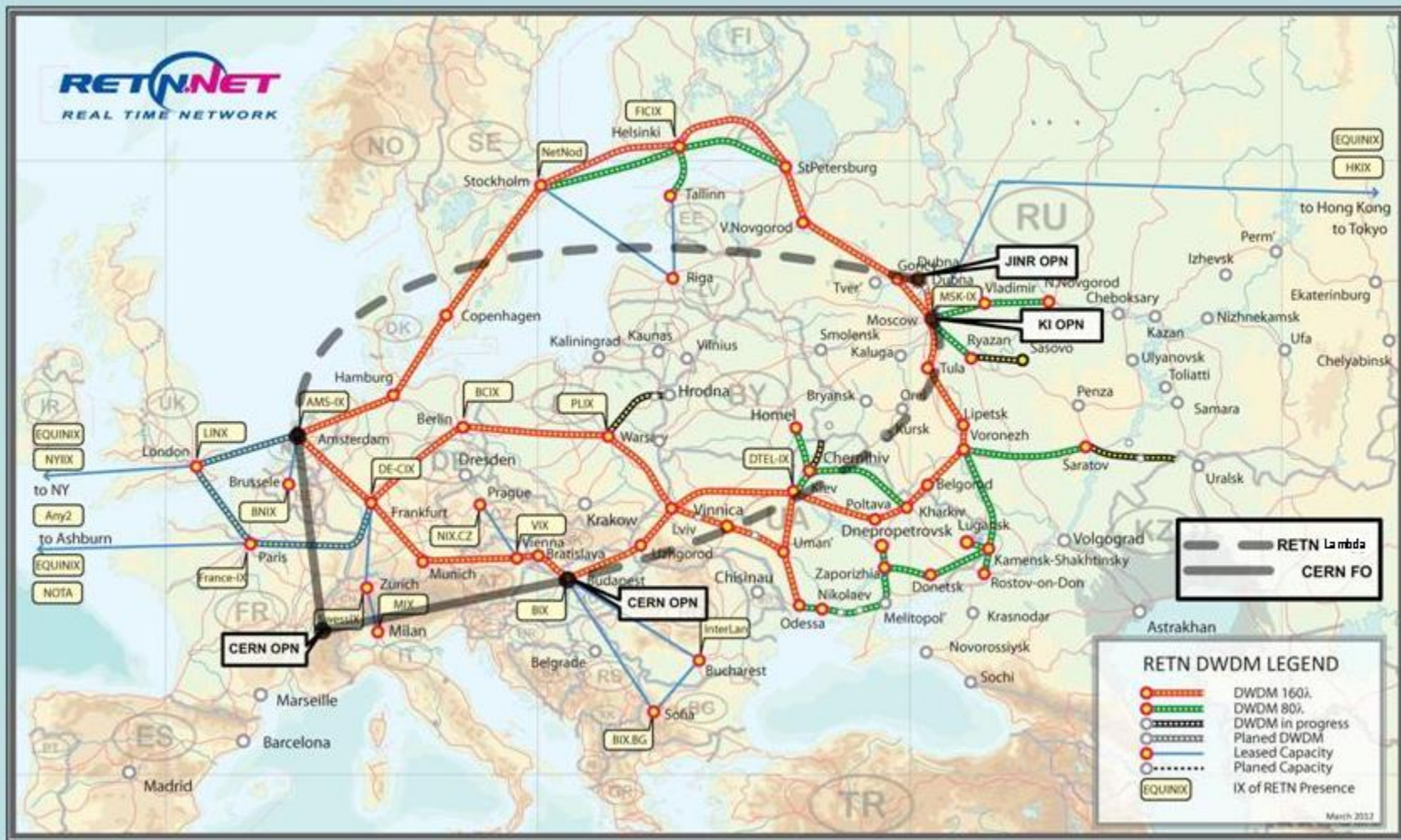
I am at your disposal for any assistance or to provide further details of the process.

Yours Sincerely,

Dr. Ian Bird  
LHC Computing Grid Project Leader  
IT Department  
CERN

Cc: Prof. Sergio Bertolucci, Dr. Viacheslav Ilyin

# JINR Tier1 Connectivity Scheme

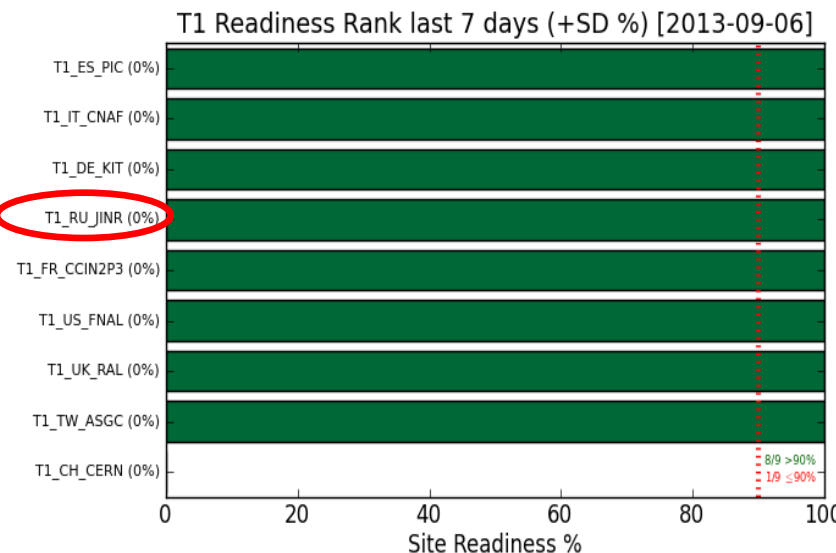


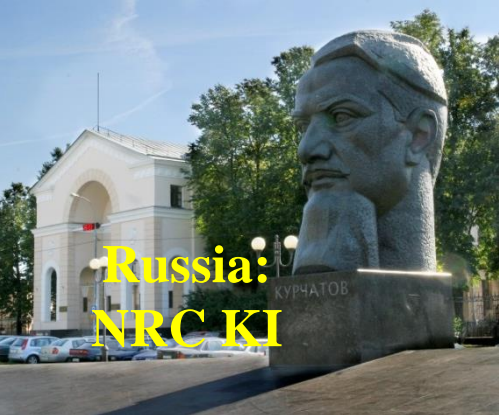
# Создание CMS Tier-1 в ОИЯИ

	2013	2014	2015	2016
<b>CPU (HEPSpec06)</b>	<b>28800</b>	<b>57600</b>	<b>69120</b>	<b>82944</b>
<b>Number of core</b>	<b>2400</b>	<b>4800</b>	<b>5760</b>	<b>6912</b>
<b>Disk (Terabytes)</b>	<b>3500</b>	<b>4500</b>	<b>5400</b>	<b>6480</b>
<b>Tape (Terabytes)</b>	<b>5700</b>	<b>8000</b>	<b>9600</b>	<b>10520</b>
<b>Link CERN-JINR</b>	<b>10</b>	<b>10</b>	<b>40</b>	<b>40</b>



- Инженерная инфраструктура (система бесперебойного электропитания, климат-контроля);
- Высокоскоростная надежная сетевая инфраструктура с выделенным резервируемым каналом в ЦЕРН (LHCOPN);
- Вычислительная система и система хранения на базе дисковых массивов и ленточных библиотек большой емкости;
- Надежность и доступность 100%





**Russia:**  
**NRC KI**



**S-BNL**



**Amsterdam/NIKHEF-SARA**



**Taipei/ASGC**



**Bologna/CNAF**



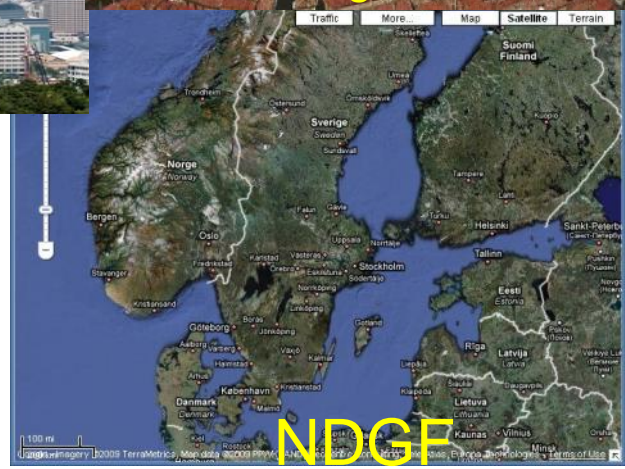
**Ca-**  
**TRIUMF**



**JINR**



**CERN**



**NIDGE**



**US-FNAL**



**De-FZK**



**Barcelona/PIC**



**Lyon/CCIN2P3**



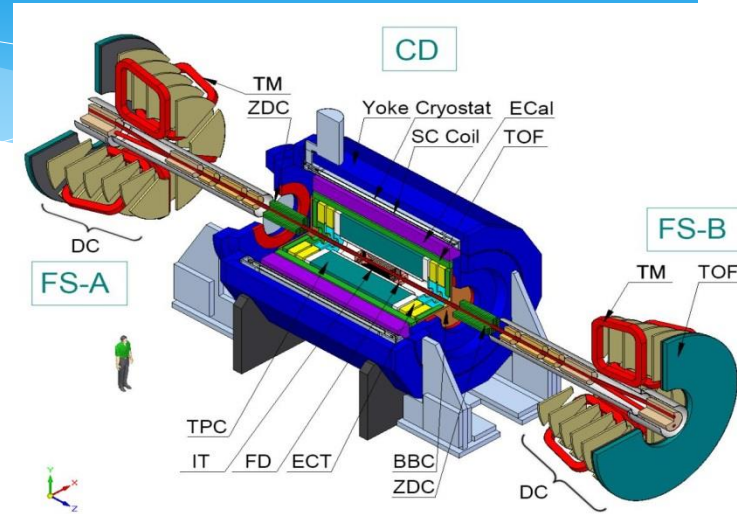
**UK-RAL**



# Frames for Grid cooperation of JINR

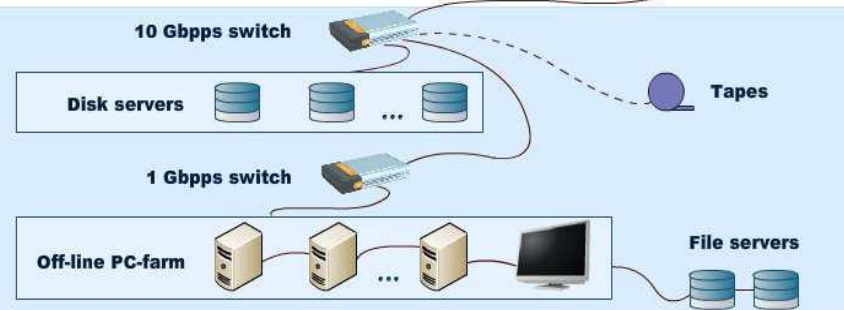
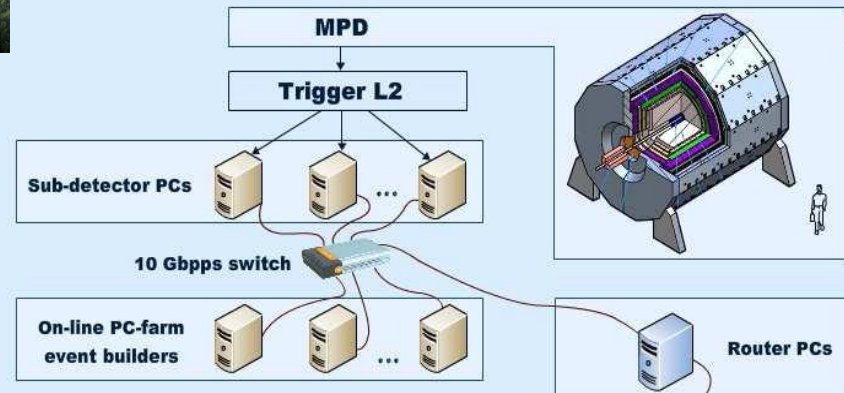
- **Worldwide LHC Computing Grid (WLCG)**
- **EGI-InSPIRE**
- **RDIG Development**
- **Project BNL, ANL, UTA** “Next Generation Workload Management and Analysis System for BigData”
- **Tier1 Center in Russia** (NRC KI, LIT JINR)
- **6 Projects at CERN**
- **CERN-RFBR project** “Global data transfer monitoring system for WLCG infrastructure”
- **BMBF grant** “Development of the grid-infrastructure and tools to provide joint investigations performed with participation of JINR and German research centers”
- “Development of grid segment for the LHC experiments” was supported in frames of JINR-South Africa cooperation agreement;
- **Development of grid segment at Cairo University and its integration to the JINR GridEdu infrastructure**
- **JINR - FZU AS Czech Republic Project** “The grid for the physics experiments”
- **NASU-RFBR project** “Development and support of LIT JINR and NSC KIPT grid-infrastructures for distributed CMS data processing of the LHC operation”
- **JINR-Romania cooperation Hulubei-Meshcheryakov programme**
- **JINR-Moldova cooperation (MD-GRID, RENAM)**
- **JINR-Mongolia cooperation (Mongol-Grid)**

# Ускорительный комплекс НИКА



Для проекта НИКА поток данных имеет следующие параметры:

- высокая скорость набора событий (до 6 КГц),
- в центральном столкновении Au-Au при энергиях НИКА образуется до 1000 заряженных частиц,
- Прогнозируемое количество событий 19 миллиардов;
- общий объем исходных данных может быть оценен в 30 PB ежегодно, или 8.4 PB после обработки.



# MMCP 2013

## Mathematical Modeling and Computational Physics



Dubna, Russia, July 8 - July 12, 2013

### Preliminary topics:

- distributed and parallel computing in science and technology;
- mathematical methods and tools for modeling complex systems;
- computational biophysics and chemistry, bioinformatics;
- mathematical methods and software for experimental data processing
- computer algebra and quantum computing with applications.

### Important dates:

- Presentation of abstracts - May 20, 2013
- Visa support - May 15, 2013
- Registration of participants - June 10, 2013
- Arrival and hotel accommodation - July 7 - 13, 2013
- Conference: July 8 - 12, 2013
- Departure: July 12-13, 2013

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# NEC'2013



XXIV International Symposium on Nuclear Electronics & Computing

BULGARIA, VARNA, 09-16 September, 2013

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