LHC Computing Grid LCG

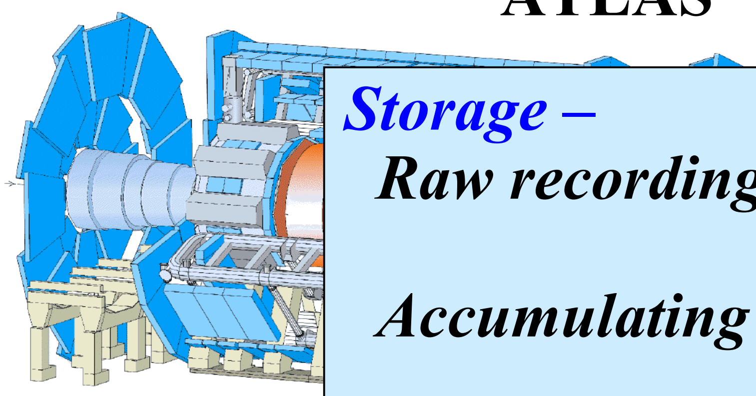
Introduction to Launching Workshop, 1st LCG week

H F Hoffmann 10-Mar-02

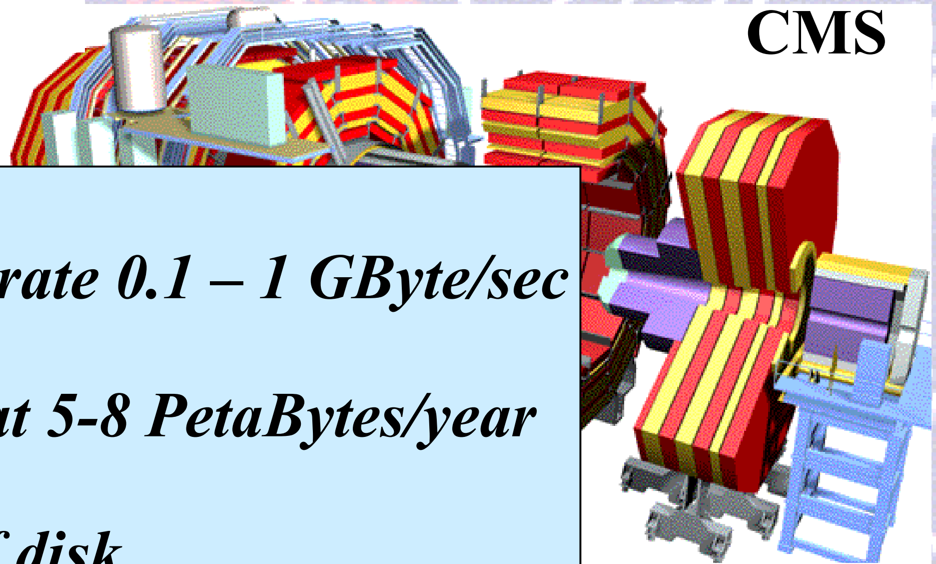
- LHC: Unprecedented amounts of complex data
- > 5000 users in ~ 50 countries
- High throughput computing
- Commodity components
- Global deployment of large-scale Grid technology

The Large Hadron Collider Project
4 detectors

ATLAS



CMS



Storage –

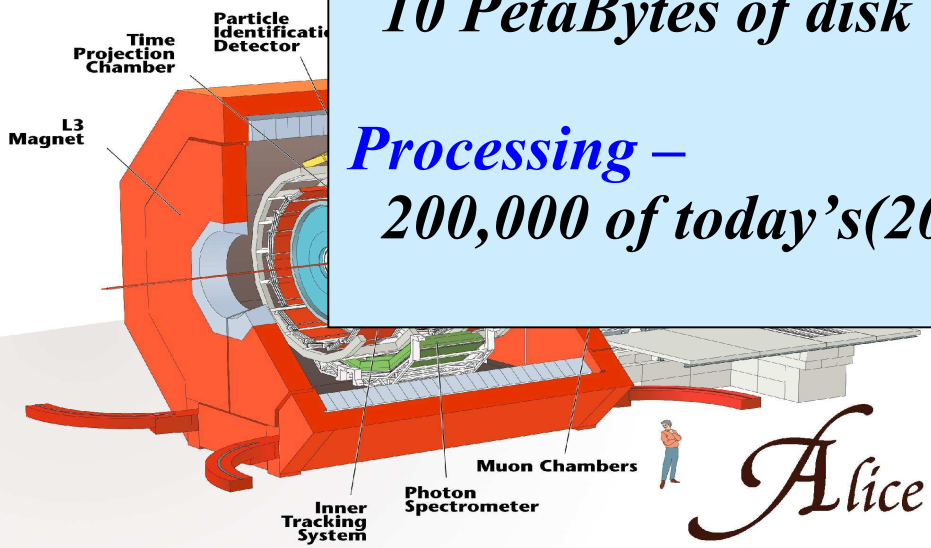
Raw recording rate 0.1 – 1 GByte/sec

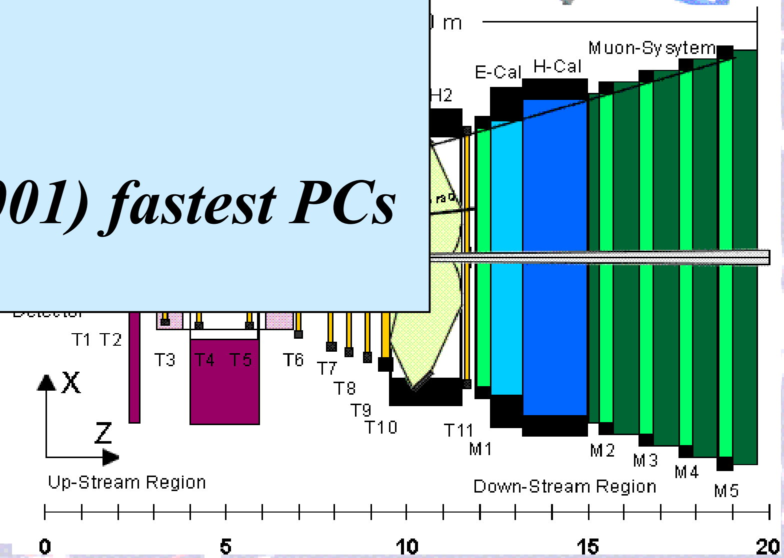
Accumulating at 5-8 PetaBytes/year

10 PetaBytes of disk

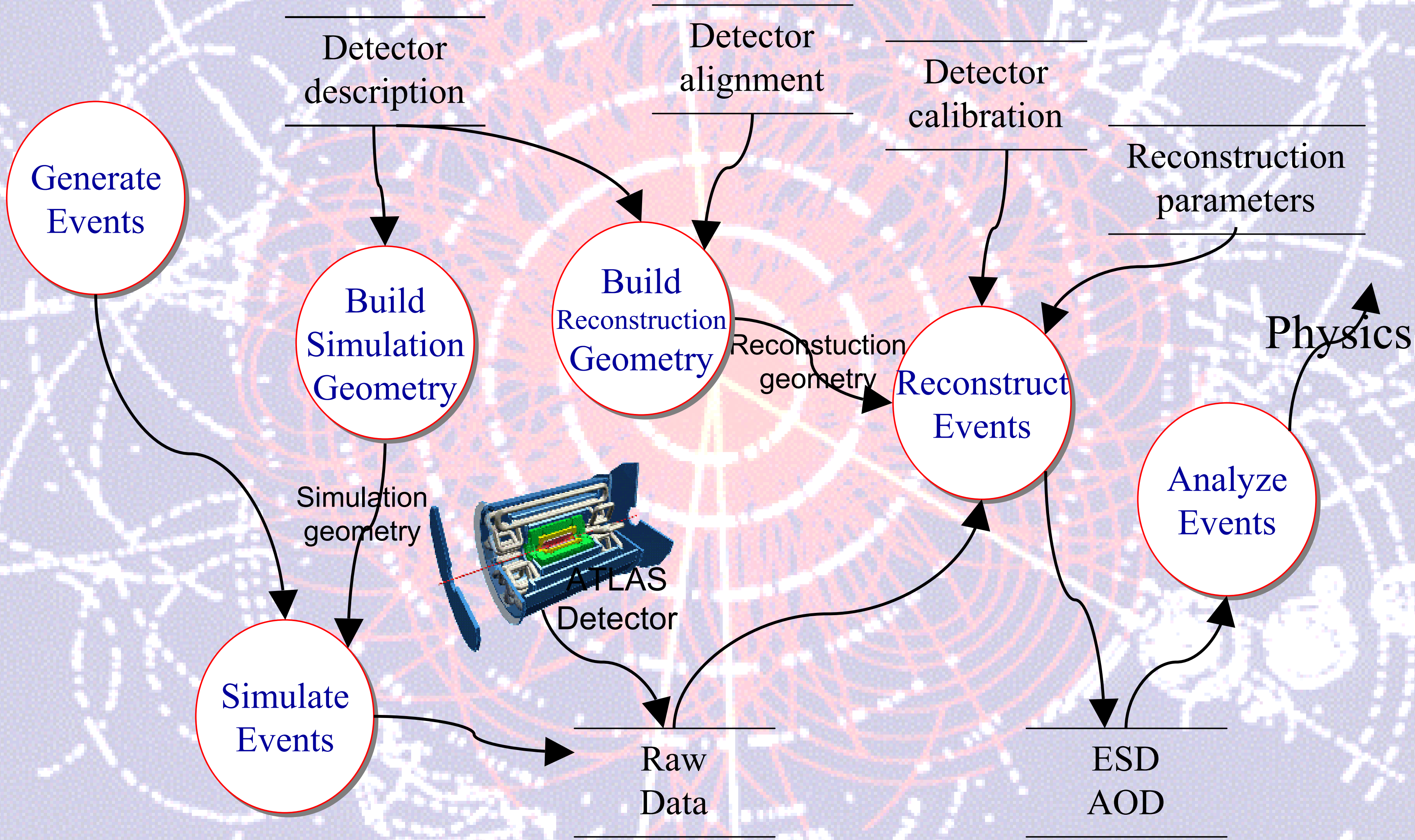
Processing –

200,000 of today's(2001) fastest PCs





Software


Detector description
Detector alignment
Detector calibration
Reconstruction parameters
Generate Events
Build Simulation Geometry
Build Reconstruction Geometry
Reconstuction geometry
Reconstruct Events
Physics
Analyze Events
Simulation geometry
ATLAS Detector
Simulate Events
Raw Data
ESD AOD

Large Collaborations

270 institutes in Europe, 4100 scientists; 210 institutes elsewhere, 1600 scientists
1 LHC experiment: ~1/3 of total

High Energy Physics Computing
High Throughput Computing

- ✓ Large numbers of independent events - trivial parallelism
- ✓ Small records - mostly read-only
- ✓ Modest I/O rates - few MB/sec per fast pro...
- ✓ Modest floating point requirem... ...performance

Good fit for clusters of PCs

☹ Chaotic workload –

- research environment ➔ unpredictable, no limit to the requirements

☹ Very large **aggregate** requirements – computation, data, i/o

- exceeds the capabilities of a single geographical installation
- scaling up is not just big – it is also complex

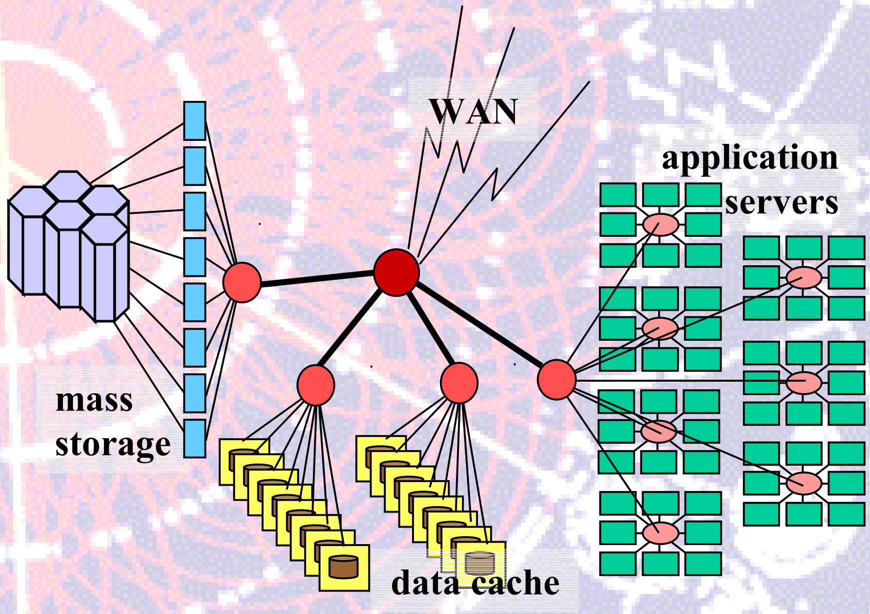
Management of Grid Nodes

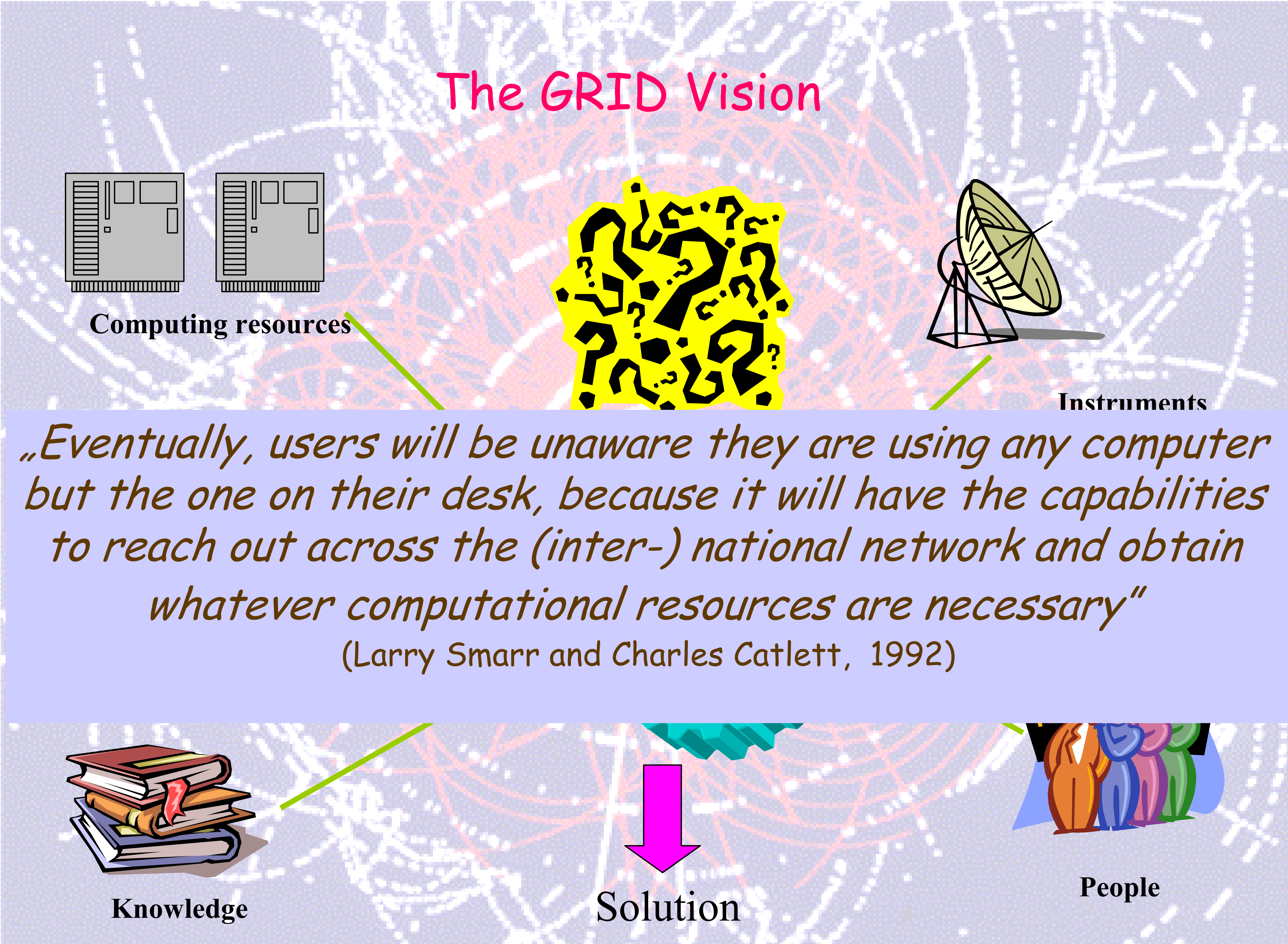
Before tackling the Grid, better know how to manage efficiently giant local clusters → *fabrics*

- commodity components – processors, disks, network switches
- massive mass storage
- new level of automation required

Key Issues –

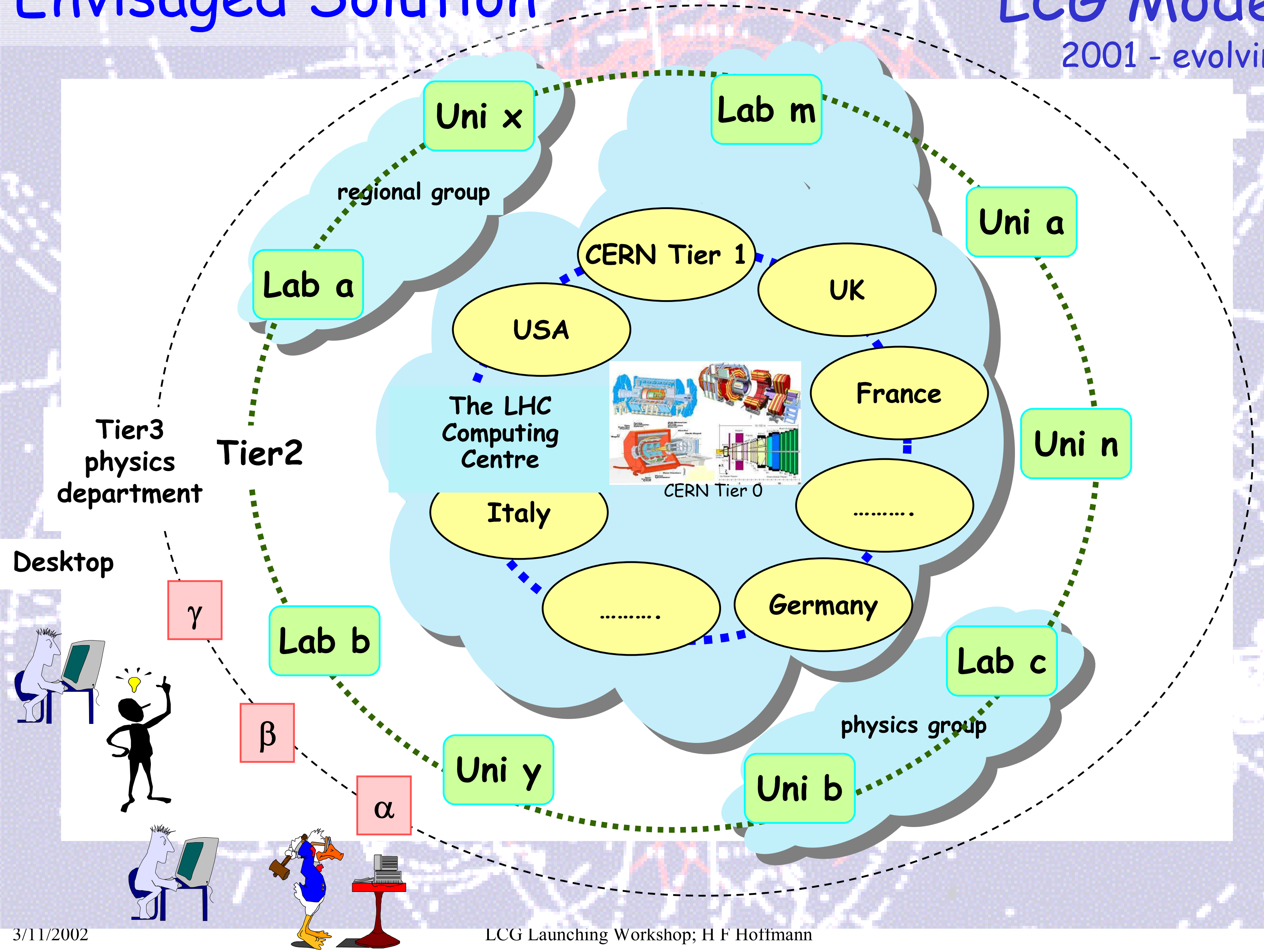
- scale
- efficiency & performance
- resilience – fault tolerance
- cost – acquisition, maintenance, operation
- usability
- security




The GRID Vision
Computing resources
Instruments
„Eventually, users will be unaware they are using any computer but the one on their desk, because it will have the capabilities to reach out across the (inter-) national network and obtain whatever computational resources are necessary"
(Larry Smarr and Charles Catlett, 1992)
Knowledge
Solution
People

Envisaged Solution

LCG Model
2001 - evolving



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Computing Review

- LHC computing is an unprecedented challenge for the communities of HEP and IT, and is a vital prerequisite for the success of LHC!

- LHC offline computing was not included in detector costs (MoU's of 1995), nor in recent estimates of detector M&O

  Reason: severe uncertainties in extrapolating more than 5 years ahead of time in this vastly developing field

- Now, 5 years before LHC start-up, it is appropriate (and also about time) to finalise LHC computing plans, to seriously start prototyping the planned system, and to secure funds and human resources to ensure timely completion.

CERN/LHCC/2001-004
CERN/RRB-D 2001-3
Original: English
22 February 2001

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE

CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

REPORT OF THE STEERING GROUP*

OF THE LHC COMPUTING REVIEW

http://lhc-computing-review-public.web.cern.ch

(Executive Summary - the LHC computing model)

1. review accepts scale of resource requirements of exp.s

2. recommend distributed, hierarchical model à la MONARC

Tier-0:	at CERN;	raw data storage; reconstruction; ...
Tier-1:	regional/supranational;	analysis, MC generation, storage, ...
Tier-2:	national/intranational;	
Tier-3:	institutional;	
Tier-4:	end-user workstations	

3. GRID technology to be used (efficient resource usage, rapid turnaround)

4. need well-supported Research Networking of 1.5–3 Gbps (for each experiment), at affordable costs, by 2006.

Summary of Computing Capacity Required for all LHC Experiments in 2007

source: CERN/LHCC/2001-004 - Report of the LHC Computing Review - 20 February 2001

(ATLAS with 270Hz trigger)

	Regional Centres	***Grand Total***
Processing (K S	4,974	7,533
Disk (PB)	8.7	11.1
Magnetic tape (F	20.3	37.9

Importance of cost containment

- components & architecture
- utilisation efficiency
- maintenance, capacity evolution
- personnel & management costs
- ease of use (usability efficiency)

- Worl
- Small
- ESD a
  - hc
  - es cs environment
- Data exchange - with tens of smaller regional centres, universities, labs

(Executive Summary - Software)

5. recommend joint efforts and common projects between experiments and CERN-IT; support for widely used products

6. perform data challenges of increasing size and complexity

7. CERN should sponsor transition to OO programming

8. identified areas of concern:
   - limited maturity of current planning and resource estimates
   - insufficient development and support of simulation packages
   - insufficient support and future evolution of analysis tools

(Executive Summary - Management and Resources)

9. Current cost estimates based on forecast evolution of price and performance of computer hardware

10. hardware costs of initial set-up of LHC distributed computer centres (Tier-0 to -2): 240 MCHF

CERN-based Tier-0+1 centre: about 1/3 of total.

Significant uncertainties due to performance of LHC, detectors, triggers, backgrounds ...

11. investment for initial system to be spent in 2005, 2006 and 2007, in ~ equal portions (assuming LHC start-up in 2006 and reach of design luminosity in 2007)

12. major concern: core software teams severely understaffed

(Executive Summary - Management and Resources)

13. planned reduction of CERN-IT staff: incompatible with CERN-based LHC computing system and software support

14. M&O of LHC computing system: rolling replacement within constant budget: requires ~ 1/3 of initial investment per year (~ 80 MCHF world-wide) - includes steady evolution of capacity

15. set-up of a common prototype as joint project (experiments, CERN-IT, major regional centres), reaching ~50% of overall computing complexity of 1 LHC experiment by ~2003/4

    (estimated costs: ~ 18 MCHF - not included in initial invest.costs)

16. set up agreement about construction & cost sharing of prototype - now!

(Executive Summary – general recommendations)

17. Set up LHC Software and Computing Steering Committee (SC2) composed of highest level software and computing management in experiments, CERN-IT and regional centres to steer deployment of entire LHC hierarchical system

18. SC2 establishes Technical Assessment Groups (TAG's) to prepare and initiate certain tasks and projects

19. Each collaboration must prepare a MoU for LHC computing describing funding and responsibilities for hard- and software, human resources etc.
    IMoU's or prototype/software agreements by end of 2001.

CERN/2379/Rev: Proposal for building the LHC computing environment at CERN (Phase 1)

Goals of Phase 1 of the Global LHC Computing Grid project

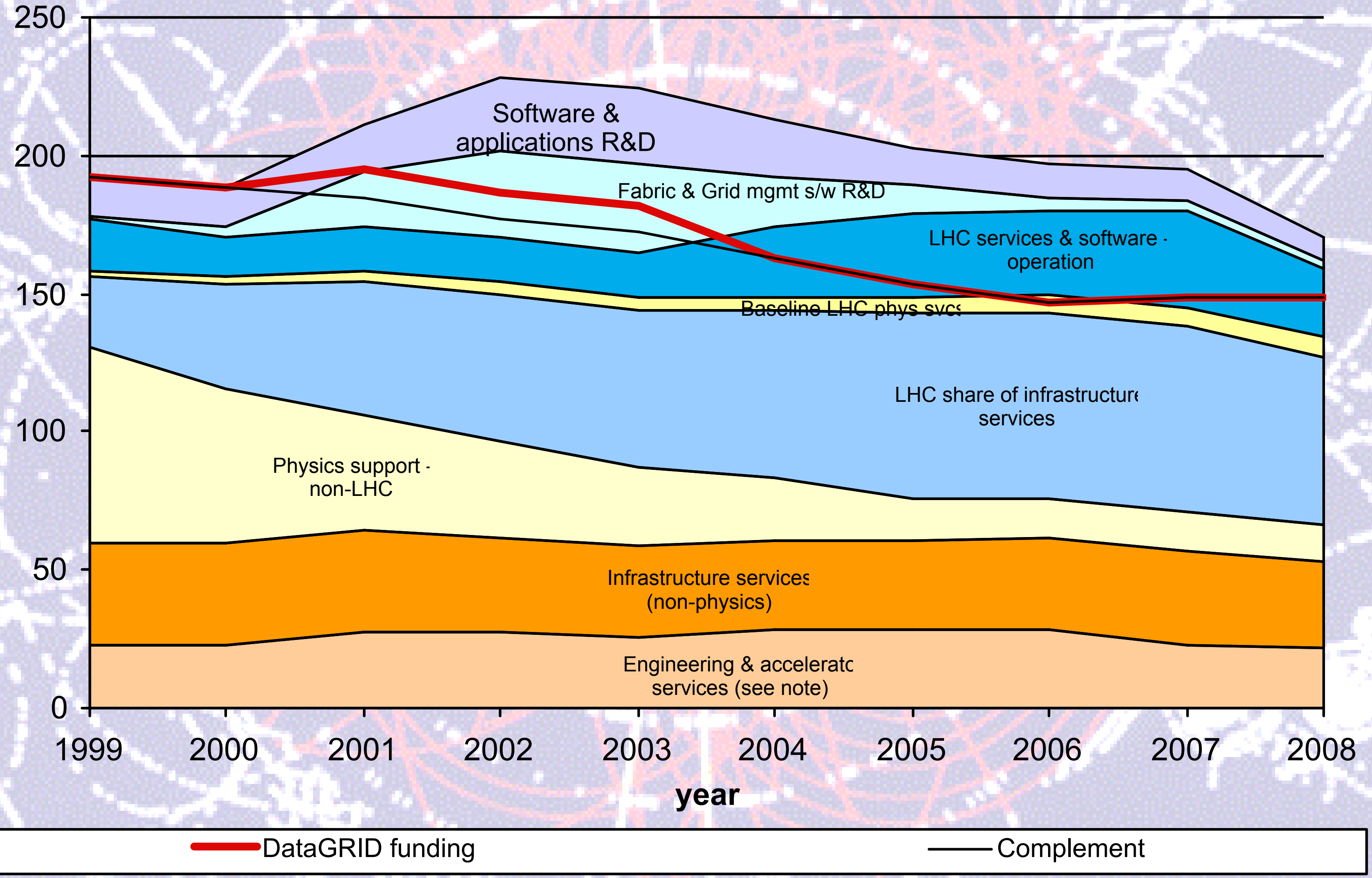
- Technology development and data challenges of the experiments from 2001 onwards leading to a Production Prototype at CERN and in MS and NMS by 2004
- Technical Design Report in 2004 describing
    - the necessary size and cost of the production facility at CERN and elsewhere
    - agreeing the relations between the distributed Grid nodes
    - their coordinated deployment and exploitation

This Project provides for high level training and technology opportunities significant well beyond particle physics

Approved in the Council Meeting of 20-Sept-01

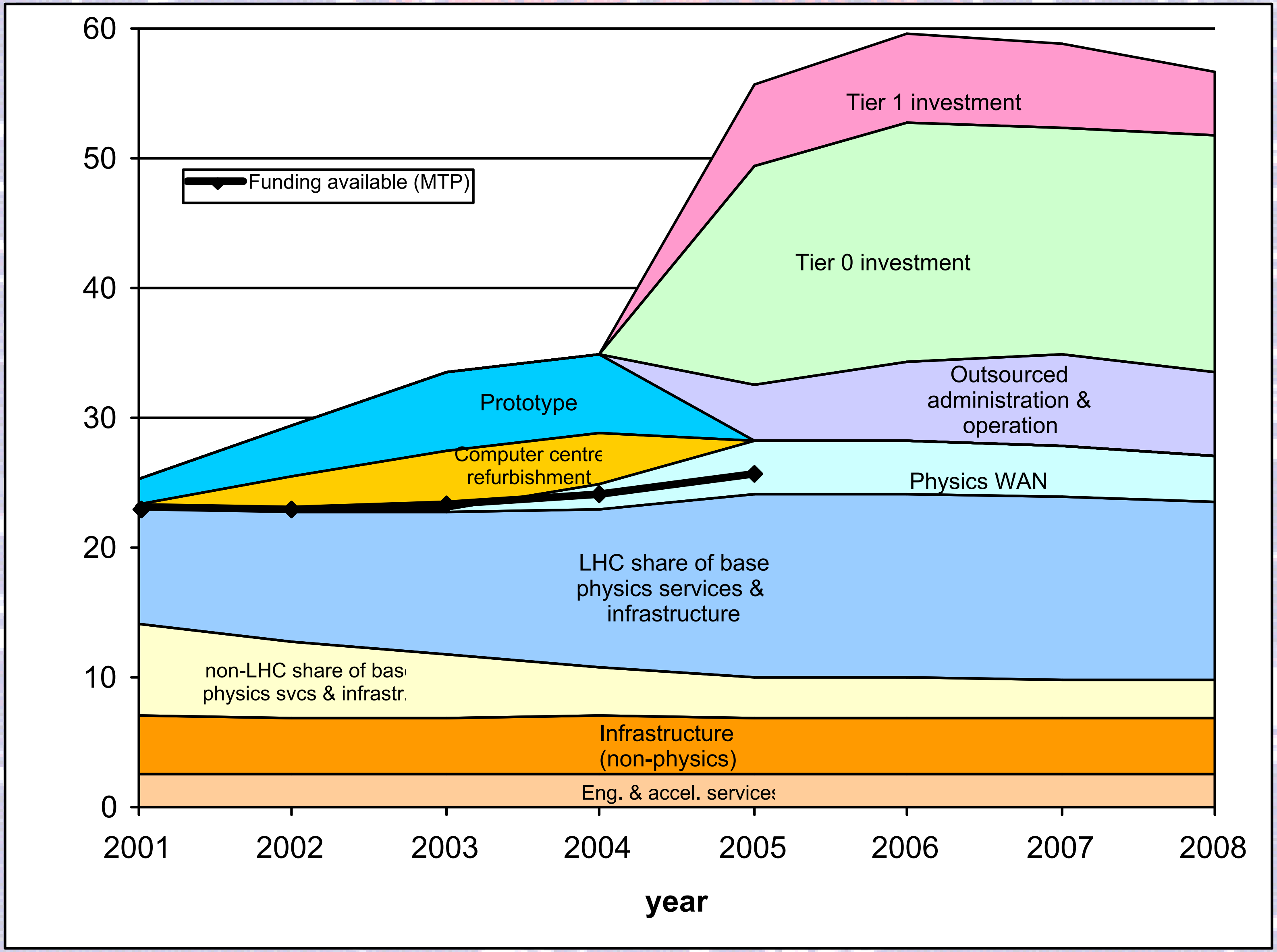
- Project Leader nominated: Les Robertson/CERN
- SC2 chair nominated: Matthias Kasemann/FNAL
- Project organisation frame
- Progress in identifying partners of LHC Computing Grid
- Contributions to Phase 1, not complete

Human Resources required for computing services at CERN (CERN/2379/Rev)



note: The numbers in this category correspond to the situation at the end of January 2001. They are higher than the figures used in the LHC Computing Review due to a shift in responsibilities to IT from the Technical and Accelerator sectors

Estimated Materials Costs for computing services at CERN (CERN/2379/Rev)



Summary of Additional Resources needed at CERN (CERN/2379/Rev)

PHASE 1

Total Phase 1

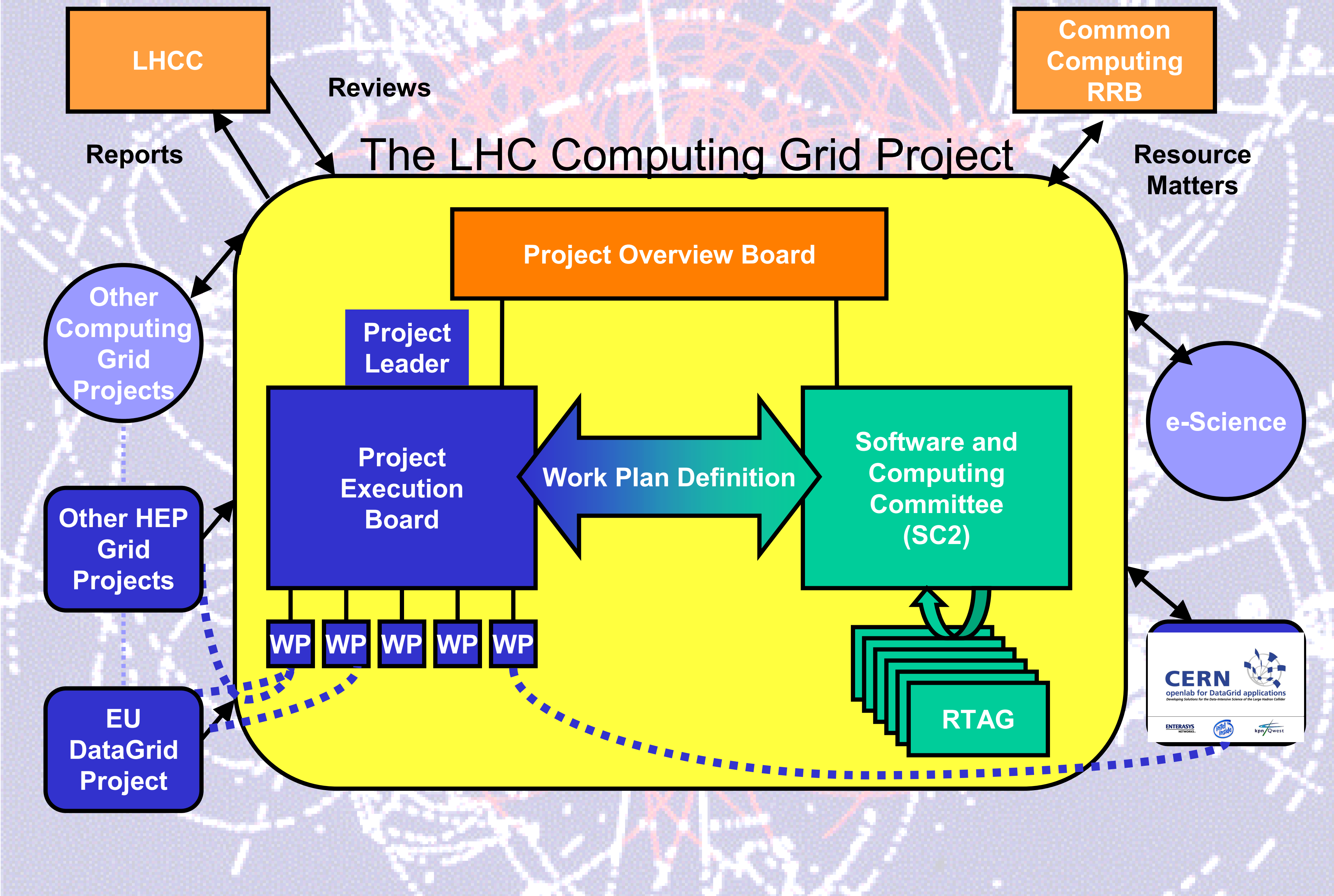
Summary - Additional Resources needed

	R&D Phase (Phase 1)				First Production System (Phase 2)			Maint-enance	Total R&D 2001-04 (Phase 1)	Total First System 2005-07 (Phase 2)
year	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*		
Services required at CERN										
Additional personnel (person-years)	**16**	**41**	**42**	**50**	**50**	**50**	**46**	**21**		
Cost if employed as CERN staff (MCHF)	2.4	6.2	6.3	7.5	7.5	7.5	6.9	3.2	*22.4*	*21.9*
Additional materials (MCHF)	2.1	6.6	10.1	10.7	30	33.4	32.4	22.6	*29.5*	*95.8*
Service funding required at CERN (MCHF)	**4.5**	**12.8**	**16.4**	**18.2**	**37.5**	**40.9**	**39.3**	**25.8**	*51.9*	*117.7*
and in addition										
Interface of experiments' Core Software to common Infrastructure										
Additional s/w professionals (person-years)	**6**	**6**	**6**	**6**	**6**	**6**				

Phase 2 under discussion with FC, . .

Total Phase 2 remains, including 10 MCHF contingency

The LHC Computing Grid Project Structure



The LHC Computing Grid Project Structure

Project Overview Board

Chair: CERN Director for Scientific Computing
Secretary: IT Division Leader

Membership:
Spokespersons of LHC experiments
CERN Director for Colliders

Representatives of countries/regions with Tier-1 center :
France, Germany, Italy, Japan, United Kingdom, United States of America

4 Representatives of countries/regions with Tier-2 center
from CERN Member States

In attendance:
Project Leader
SC2 Chairperson

Re

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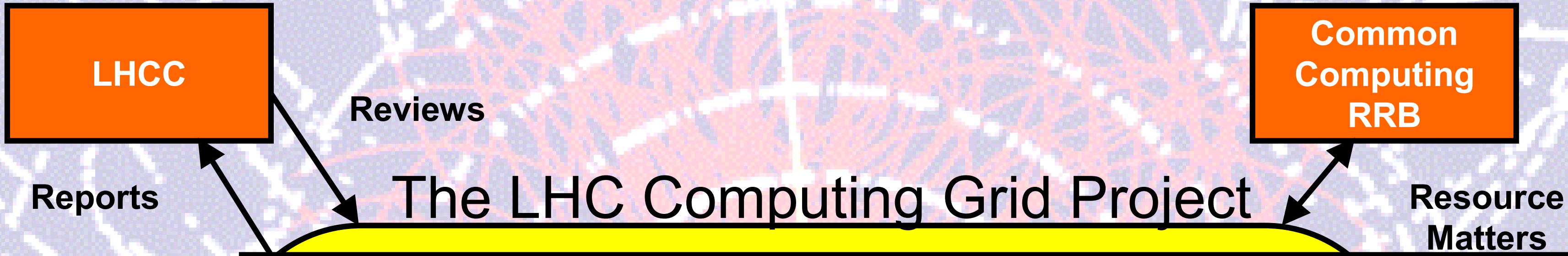
RTAG

The LHC Computing Grid Project Structure



Software and Computing Committee (SC2)

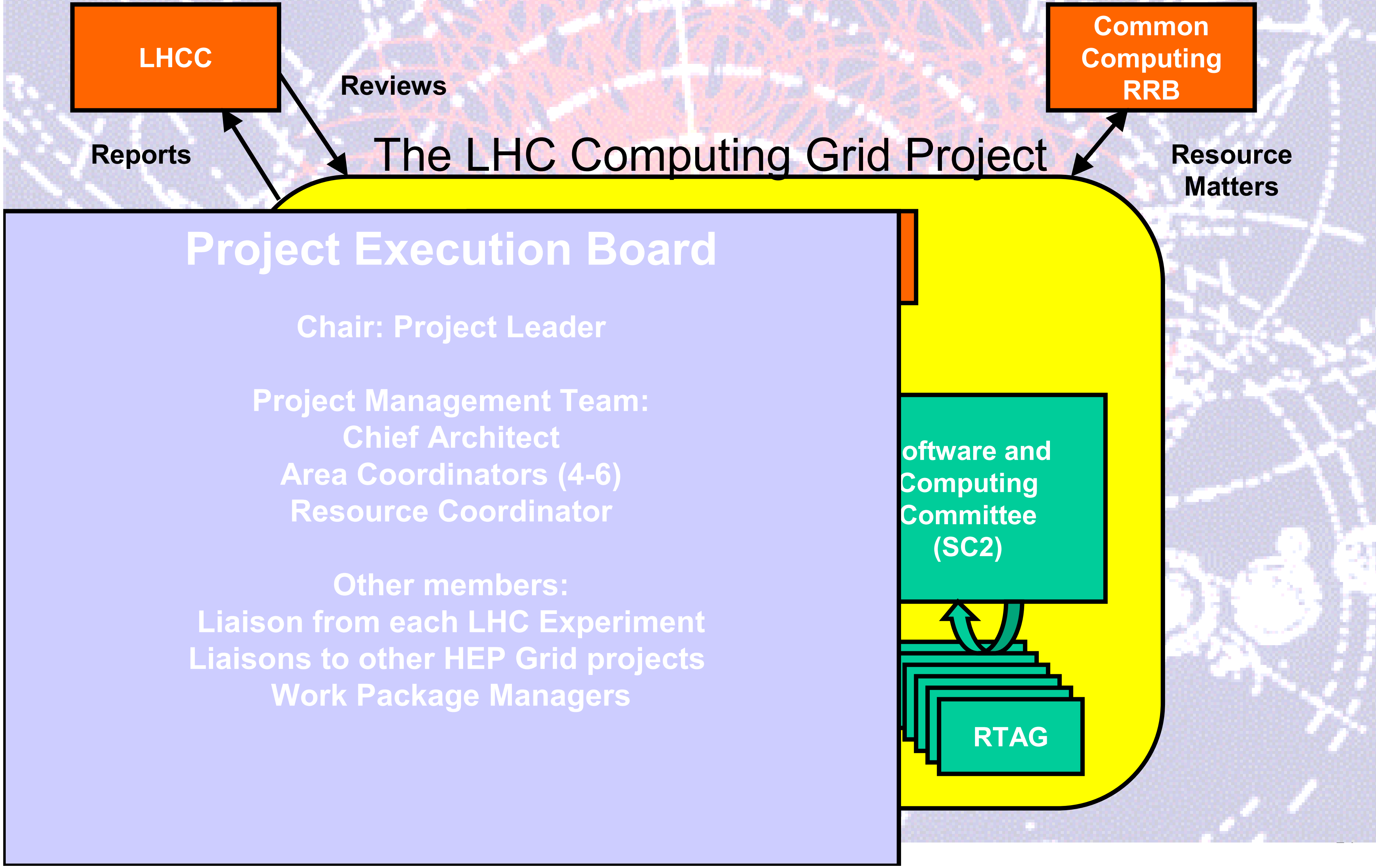
Chair: Matthias Kasemann, FNAL
Secretary

Membership:

2 coordinators from each LHC experiment
Representative from CERN EP Division
Technical Managers from centers in each region represented in the POB
Leader of the CERN Information Technology Division
Project Leader

Invited:
POB Chairperson

The LHC Computing Grid Project Structure



CERN openlab Concept

- Create synergies between basic research and industry
  - Research provides challenge
  - industry provides advanced items, concepts
  - Participation fee
- Collaborative forum between public sector and industries to solve a well defined problem through open integration of technologies, aiming at open standards

CERN
openlab for DataGrid applications
Developing Solutions for the Data-Intensive Science of the Large Hadron Collider

ENTERASYS NETWORKS
intel inside
kpnQwest

EU DataGrid Project Objectives

- To build on the emerging Grid technology to develop a sustainable computing model for effective share of computing resources and data
- Specific project objectives:
  - Middleware for fabric & Grid management (mostly funded by the EU)
  - Large scale testbed (mostly funded by the partners)
  - Production quality demonstrations (partially funded by the EU)
- To collaborate with and complement other European and US projects (i.e. of EU RN/GEANT)
- Contribute to Open Standards and international bodies:
  - Co-founder of Global GRID Forum and host of GGF1 and GGF3
  - Industry and Research Forum for dissemination of project results

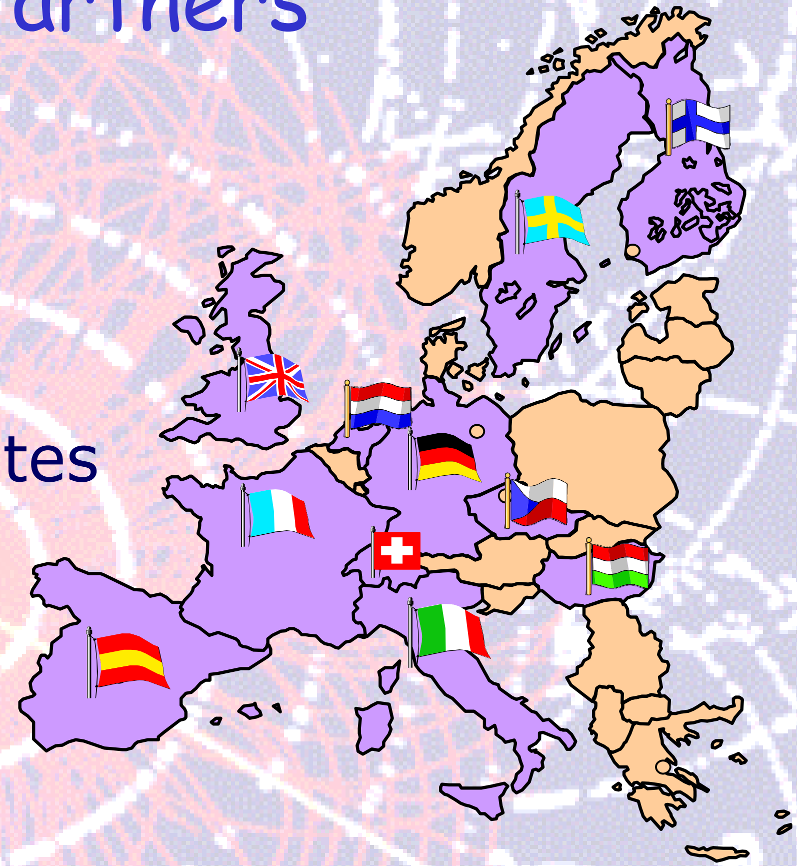
Main Partners

- CERN – International (Switzerland/France)
- CNRS - France
- ESA/ESRIN – International (Italy)
- INFN - Italy
- NIKHEF – The Netherlands
- PPARC - UK

Assistant Partners

Industrial Partners

- Datamat (Italy)
- IBM-UK (UK)
- CS-SI (France)



Research and Academic Institutes

- CESNET (Czech Republic)
- Commissariat à l'énergie atomique (CEA) – France
- Computer and Automation Research Institute, Hungarian Academy of Sciences (MTA SZTAKI)
- Consiglio Nazionale delle Ricerche (Italy)
- Helsinki Institute of Physics – Finland
- Institut de Fisica d'Altes Energies (IFAE) - Spain
- Istituto Trentino di Cultura (IRST) – Italy
- Konrad-Zuse-Zentrum für Informationstechnik Berlin - Germany
- Royal Netherlands Meteorological Institute (KNMI)
- Ruprecht-Karls-Universität Heidelberg - Germany
- Stichting Academisch Rekencentrum Amsterdam (SARA) – Netherlands
- Swedish Research Council - Sweden

Trans-Atlantic Testbeds

DataTAG – EU funding to enable Datagrid & US projects to build a common testbed

Applications

- HEP
  - The four LHC experiments
  - Live proof-of-concept prototype of the Regional Centre model
- Earth Observation
  - ESA-ESRIN
  - KNMI (Dutch meteo) climatology
  - Processing of atmospheric ozone data derived from ERS GOME and ENVISAT SCIAMACHY sensors
- Biology
  - CNRS (France), Karolinska (Sweden)

Project Schedule

- TestBed 0 (early 2001)
  - International test bed 0 infrastructure deployed
    - Globus 1 only - no EDG middleware
- TestBed 1 (now)
  - First release of EU DataGrid software to defined users within the project:
    - HEP experiments, Earth Observation, Biomedical applications
- **Project successfully reviewed by EU on March 1st 2002**
- TestBed 2 (September-October 2002)
  - Builds on TestBed 1 to extend facilities of DataGrid
- TestBed 3 (March 2003) & 4 (September 2003)
- Project end on 31-12-2003
- Project started on 1/1/2001

Major achievements to date

- Core middleware group developed innovative S/W also exported to US (GDMP and resource broker)
- Excellent collaboration with US Globus and Condor developments
- Close collaboration with similar US projects (PPDG, GriPhyN/iVDGL)
- Large community of enthusiastic, dedicated scientists
- End users involved in all stages of the project (requirements definition, architecture, S/W integration, deployment, validation and tests)
- Unfunded staff effort about twice the EU funded (voluntary participation from Portugal, Ireland, Russia & Denmark both in M/W and in the test bed) as a good measure of success for the project

more achievements, continued…

- Good relations to industry (through the I&R Forum)
- Seed funds for national Grid projects, coordinator and initiator of other projects (DataTAG, CrossGrid, GridSTART, security proposal)
- Initiator and active participant in GGF, Intergrid, EIROForum Grid WG, OCDE interest to start a WG, exploratory work in Asian Pacific and South America
- Pioneering role (EU Grid flagship project): first opportunity to work on Grid for ESA with fostering effect of internal Grid activity
- Prototype use of national RNs for Grid deployment (building Grids of Grids)

Remarks on DataGrid

- The project after just one year is up and running with 21 partners all contributing according to the contract
- First testbed deployed on 5 main sites (in France, Italy, NL, UK and CERN)
- Real applications from Biology and Medicine, Earth Observation and Particle Physics demonstrated on the test bed
- First review passed to the full satisfaction of the EU reviewers
  - Excellence of technical results and sound management commended
- EU Grid flagship role confirmed with increased visibility in the international bodies (GGF and others)
- Aggressive programme ahead to evolve towards more production quality testbeds for next two years and then?

CERN Budget Crisis

- For LHC machine and experimental areas, 475 MCHF of additional cost identified and 143 MCHF of prototyping cost to be transferred to the general budget
- PS and SPS upgrade as LHC injectors: + 26 MCHF.
- CERN's share of Expt. cost increases, C&I costs and M&O are 86 MCHF
- Construction of LHC is CERN's first priority in the years to come
- Savings of ~ 40 MCHF/year are necessary during the years 2002-2009
- Schedule for the LHC machine construction revised. Physics programme to start in April 2007
- Major re-organisation at CERN

LCG Consequences

	Estimates (MCHF)		
	CERN/2379/Rev Physics in 2006	Physics in 2007	Decrease
System construction period	2005-2007	2006-2008	
Tier 0 + 1 investment	72.3	51.3	21.0
Outsourced admin. & operation	17.6	10.9	6.7
Wide area networking for physics	12.0	11.4	0.6
Additional savings on infrastructure			0.4
Additional savings on above due to trigger rate re-evaluation			9.9
Funding to be found from external sources, EU projects, etc.			20.0
			58.6

	CERN/2379/Rev Physics in 2006	Physics in 2007	All savings & Ext. Funding
Total additional funds needed	**120.0**	**91.7**	**61.4**

An ambitious strategic goal for EU in the next decade

"...to become the most competitive and dynamic knowledge-based economy in the world..."

(Lisbon Summit 2000)

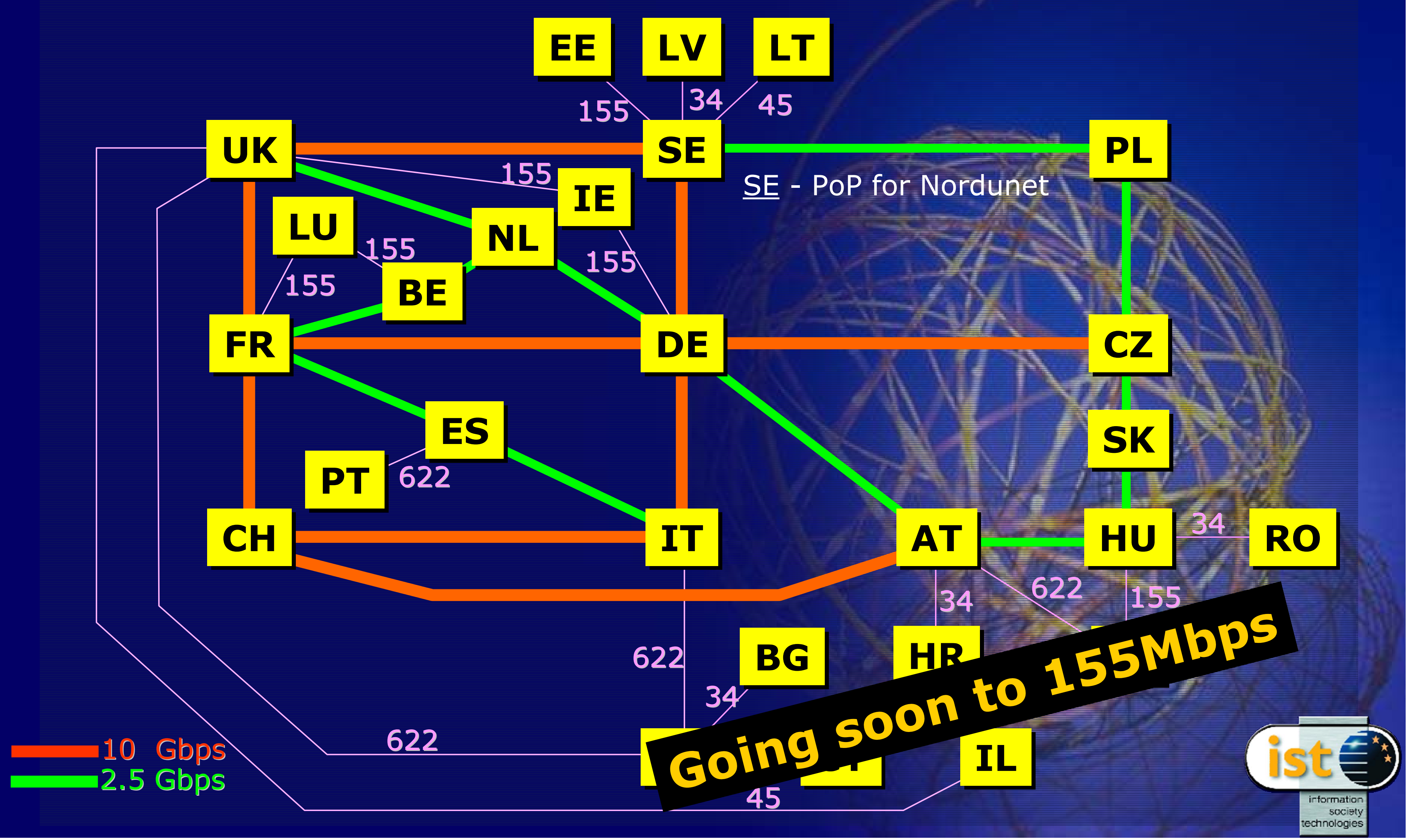
Research Networks: The funding from EU

➲ GÉANT	80 MEuro
Global connectivity	20 MEuro
SERENATE strategic study	1 MEuro

➲ GRIDS	37 MEuro
IPv6	24 MEuro
Other	8 MEuro

Mário Campolargo,private communication,not official EU view, Deputy-Head of Unit, DG INFSO, EC

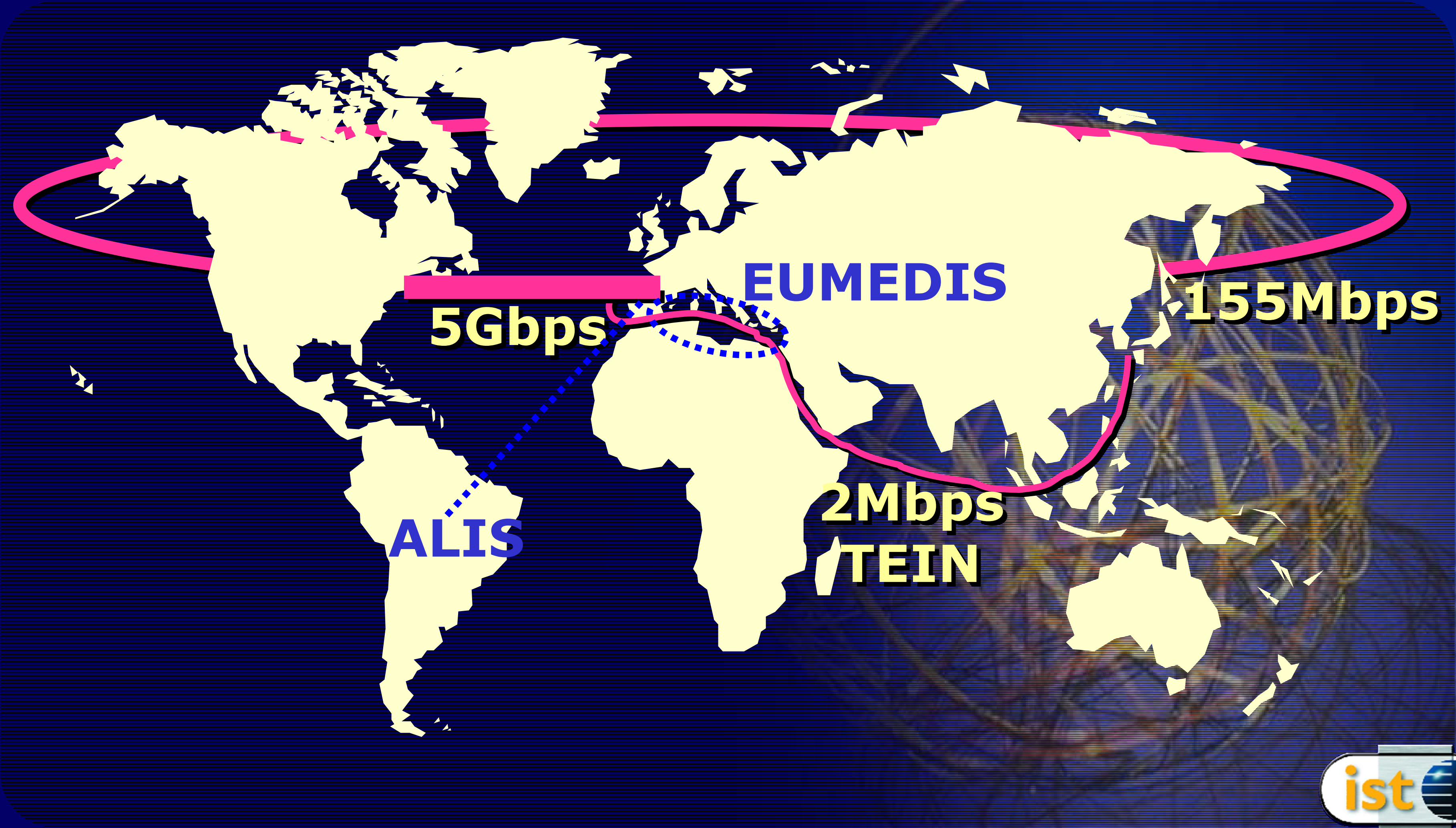
GÉANT:
The connectivity at 10 Gbps



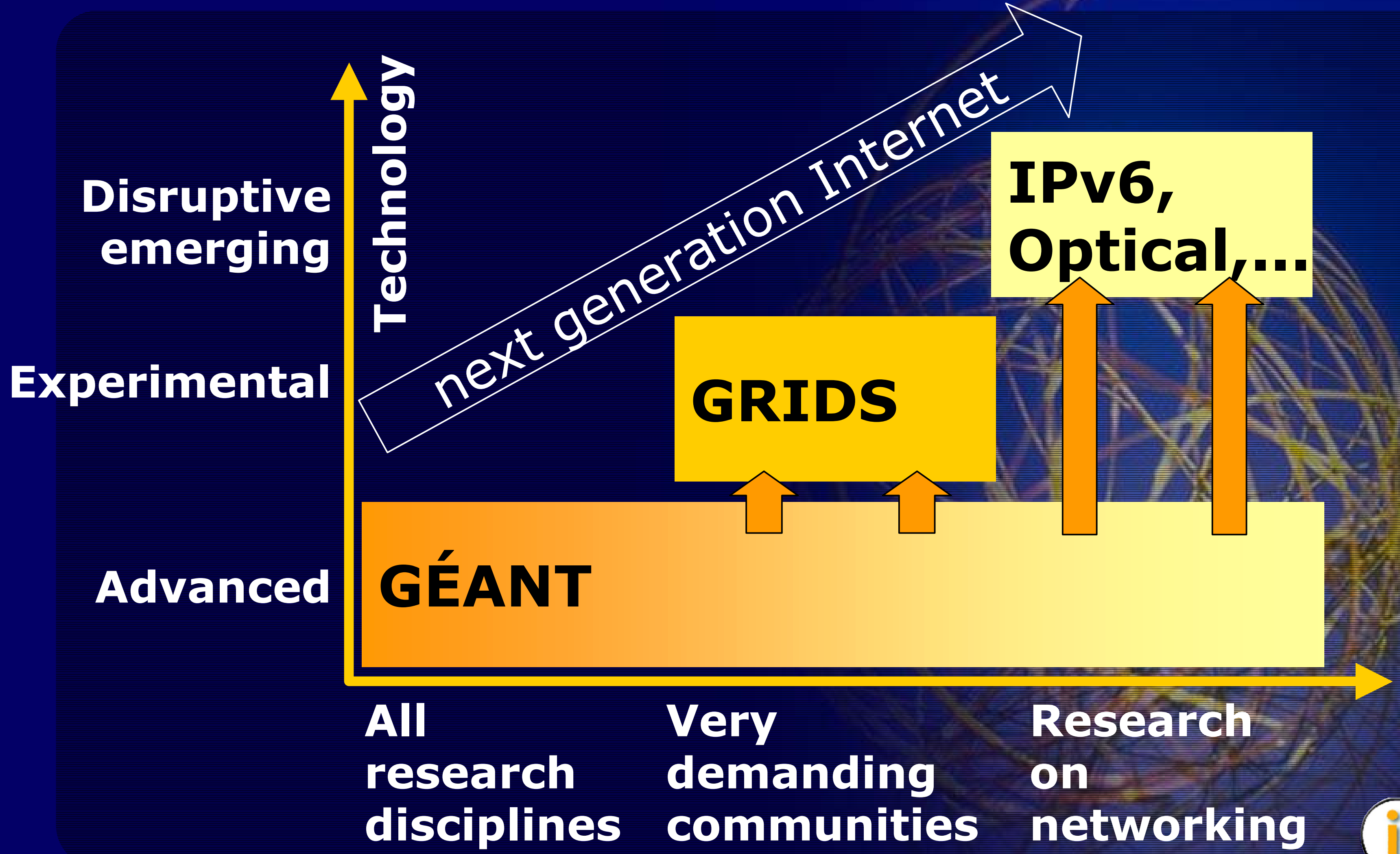
	Abilene	GÉANT	GÉANT + NRENs
Trunk Capacity	35 GB/s	120 GB/s	
No of Main Access Points	36	27	
No of Core Nodes	13	12	
Accessible Institutions	200 aprox.		> 3000

ist information society technologies

GÉANT international dimension: a world of opportunities



GÉANT:
One element of a strategy

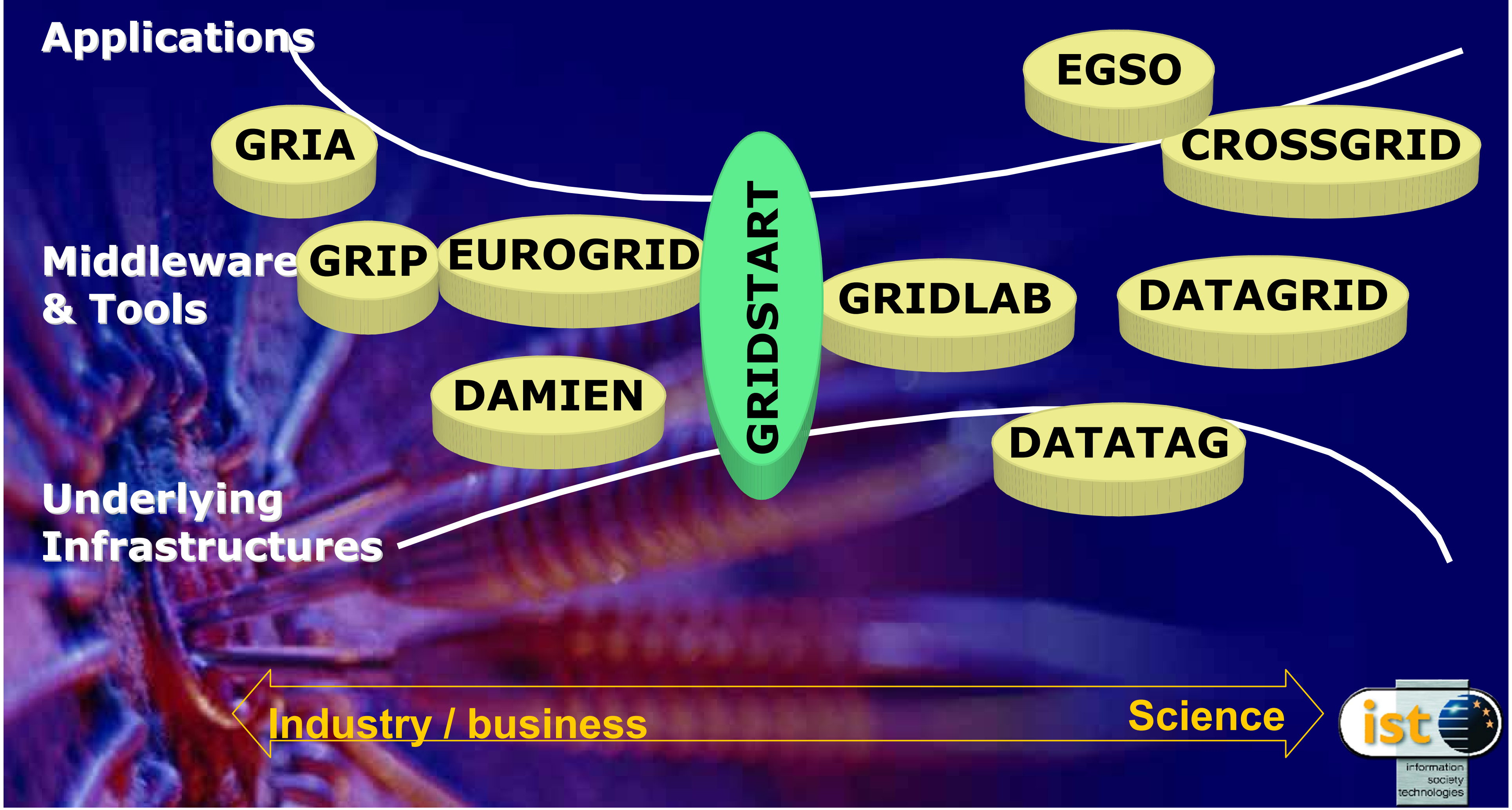


GRIDs: The European efforts

EU supported GRIDs work complements national Programmes:

- UK - eScience Programme
- Italy - INFN Grid
- Netherlands - DutchGrid
- Germany - Unicore plus
- France - Grid funding approved
- Ireland - Grid-Ireland
- Poland, Czech Republic - seed funding

GRIDs:
An integrated approach



GRIDs: Examples of large testbeds

➲ **DATAGRID, CROSSGRID**

- **17 European countries**
- **Collaboration of more than 2000 scientists**

Application requirements:

- **Computing > 20 TFlops/s**
- **Downloads > 0.5PBytes**
- **Network speeds at 10 Gbps**

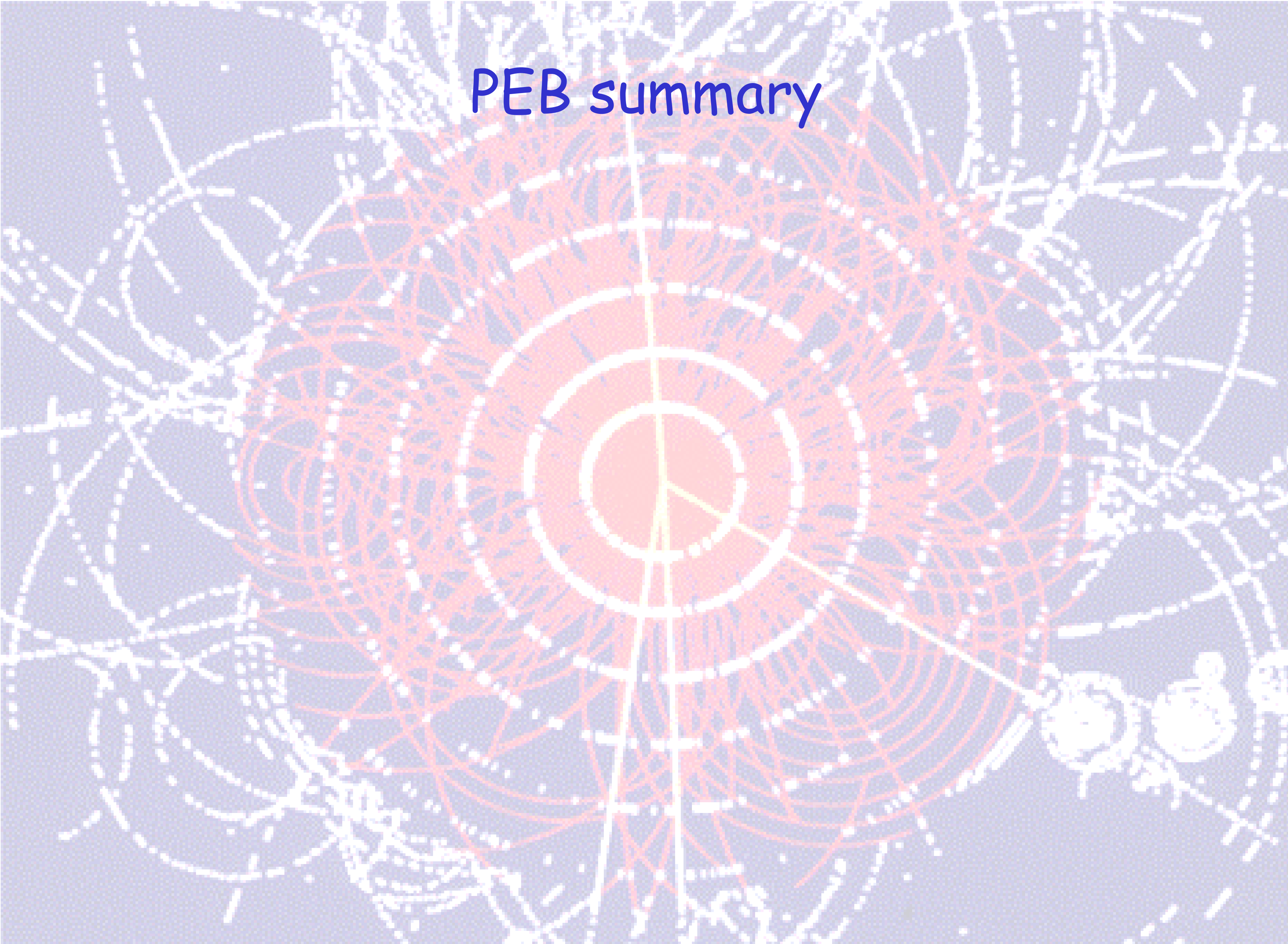
GRIDs:
Examples of large testbeds

- **DATATAG (cross-Atlantic testbed)**

Links with US projects

(GriPhyN, PPDG, iVDGL,...)

PEB summary

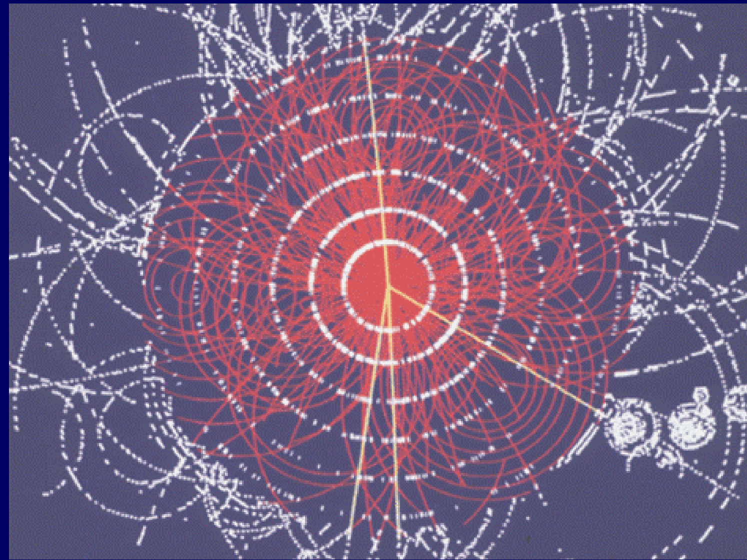


SC2 summary

Summary

- LCG is the dedicated world-wide deployment project of the infrastructure for LHC Computing and the work place for the co-ordinated computing efforts of the experiments
- LCG is a global project, based on the LHC experiments, large software efforts, (inter-) national Grid project achievements and on CERN's involved divisions
- LCG addresses many technological challenges and needs to solve them in the coming years (Phase 1)
- LCG, through the Grid projects, needs to reach out to all participating countries and their talented people, to other sciences, to industry to collect the resources
- LCG, as part of the LHC project, is top priority for CERN

- LCG, however, critically depends on its participants, their collaboration and contributions



LCG

Lets do it