CNAF al Tecnopolo e prospettive del calcolo INFN

A. Zoccoli
INFN and University of Bologna

INFN
Istituto Nazionale di Fisica Nucleare

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

Credits

The presentation is based on the work of the C3S group and of many people

Thanks to

all the people helped in the preparation of the slides: D. Lucchesi, T. Boccali, D. Bonacorsi, S. Campana, G. Carlino, L. Cosmai, D. Salomoni, P. Vicini , L. Bologni, F. Fava, R. Saban…….

OUTLINE

- Current status
- Future needs
- The strategy
- CNAF @ Tecnopolo

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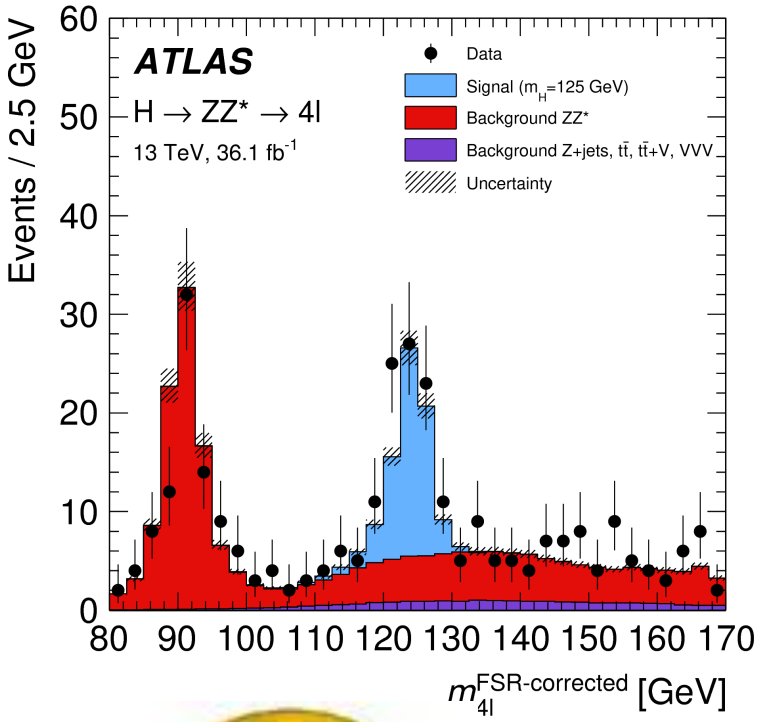
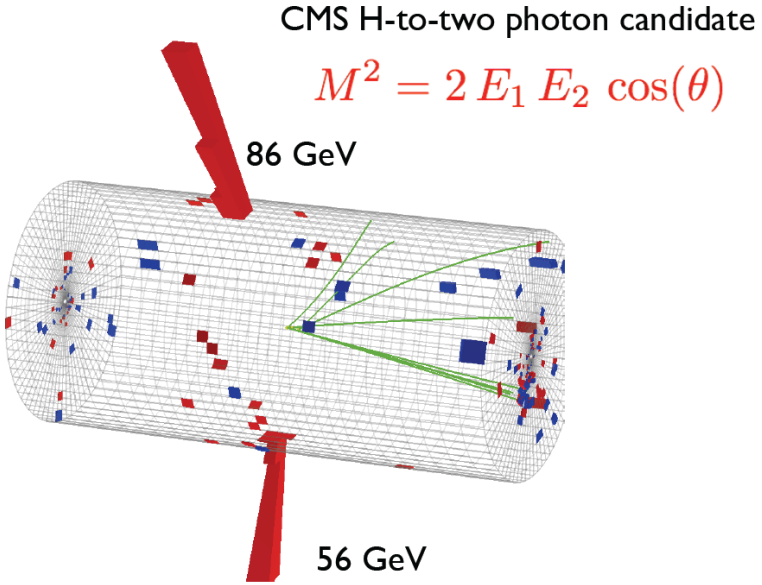
Current status

Physics results

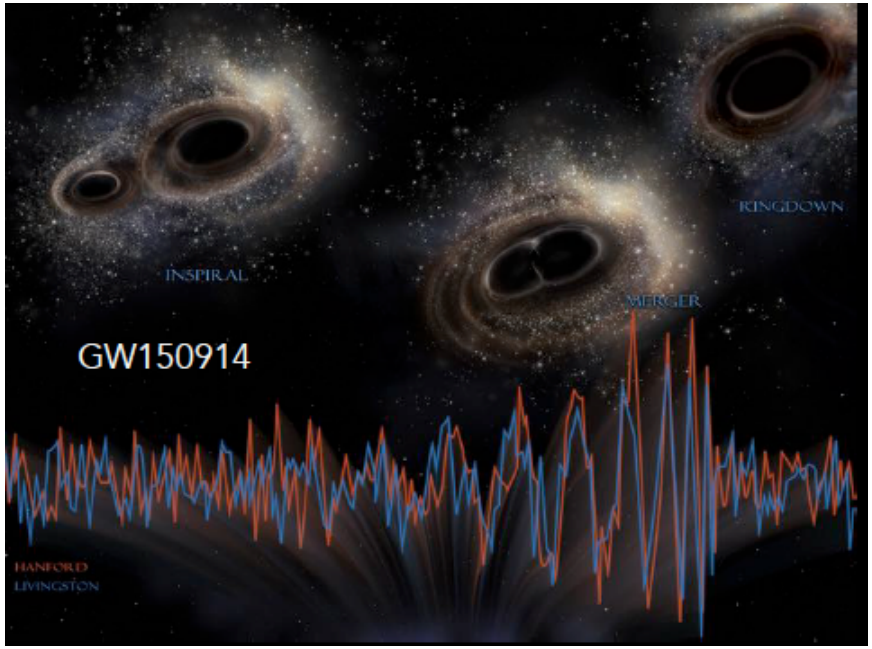


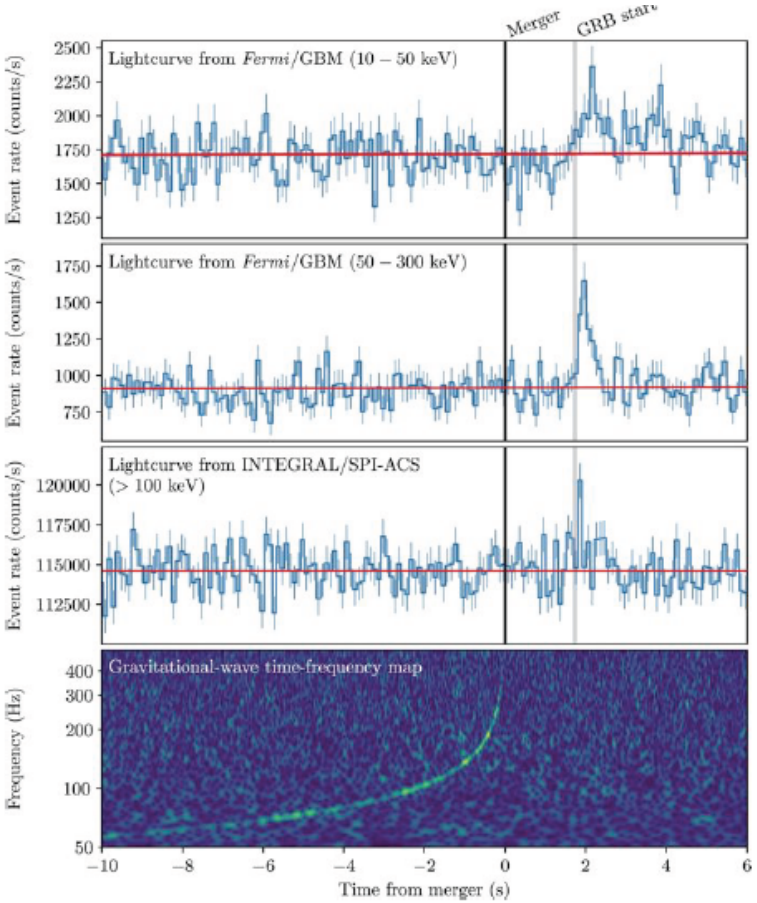


Scoperta bosone di Higgs

Premio Nobel Fisica 2013

Physics results - 2



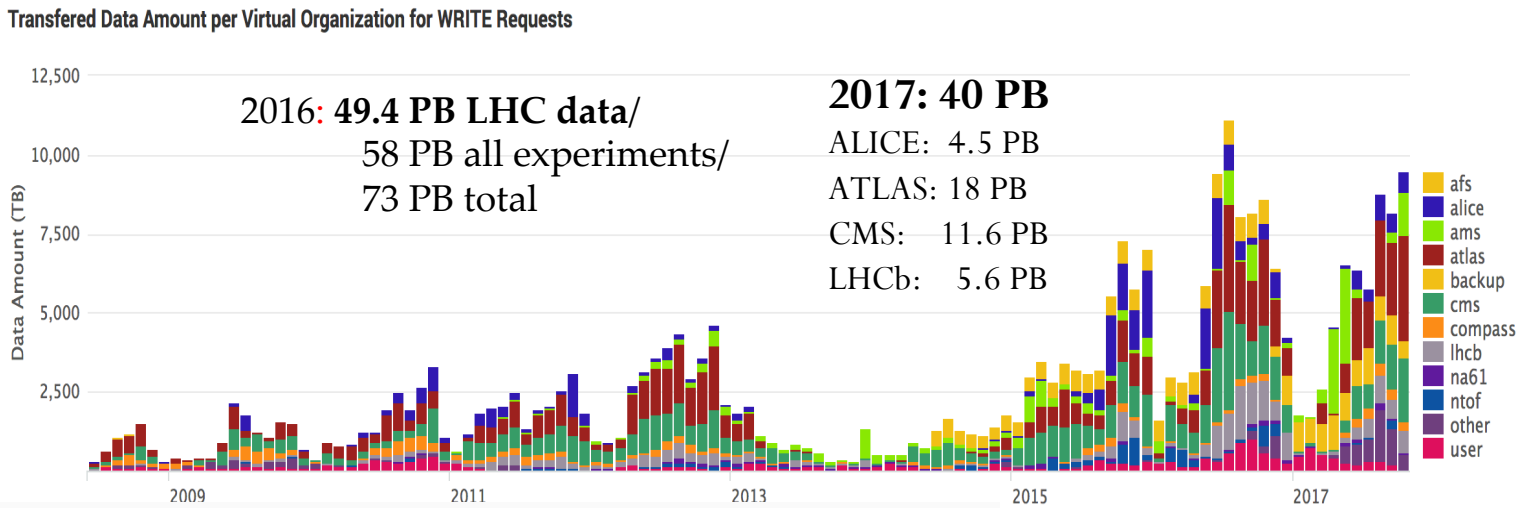


Scoperta Onde Gravitazionali

Premio Nobel Fisica 2016

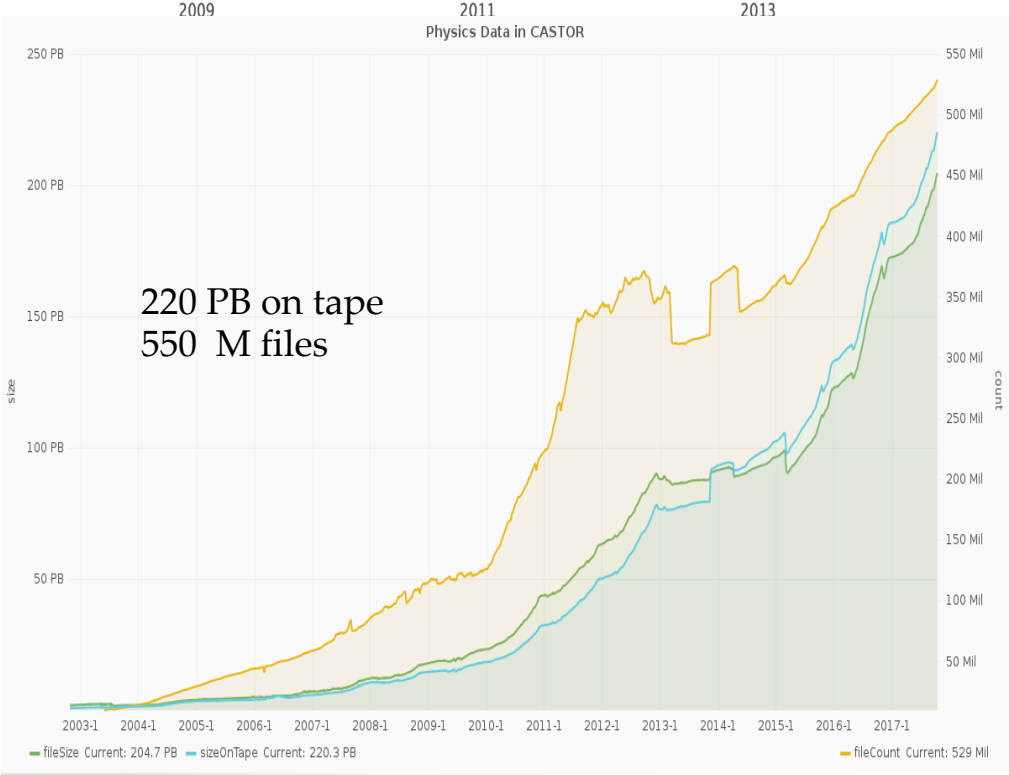
Molti dati da immagazzinare ed analizzare i tempi brevi

LHC Data

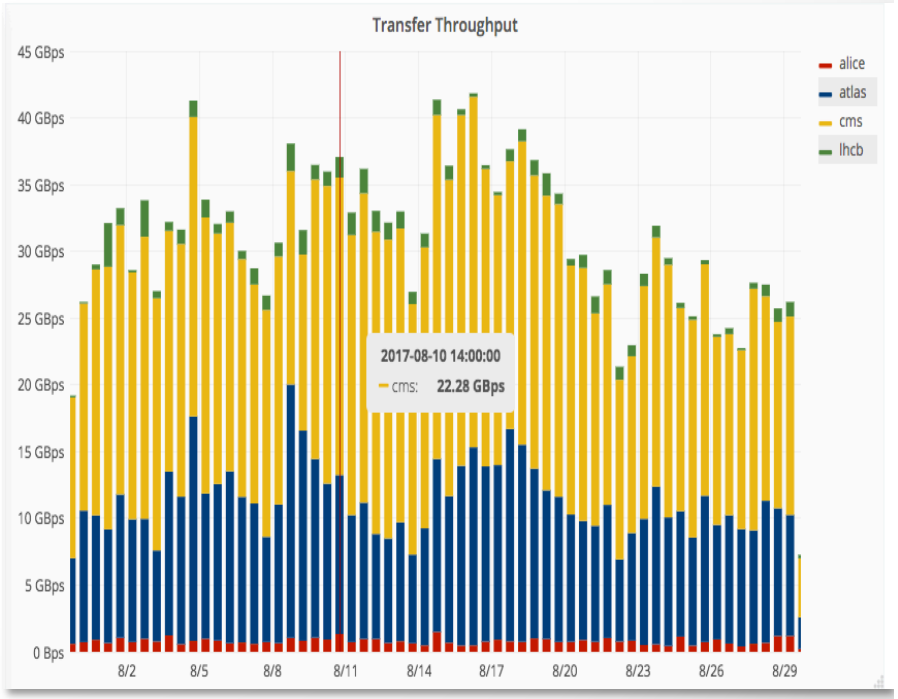


2016: **49.4 PB LHC data/**
58 PB all experiments/
73 PB total

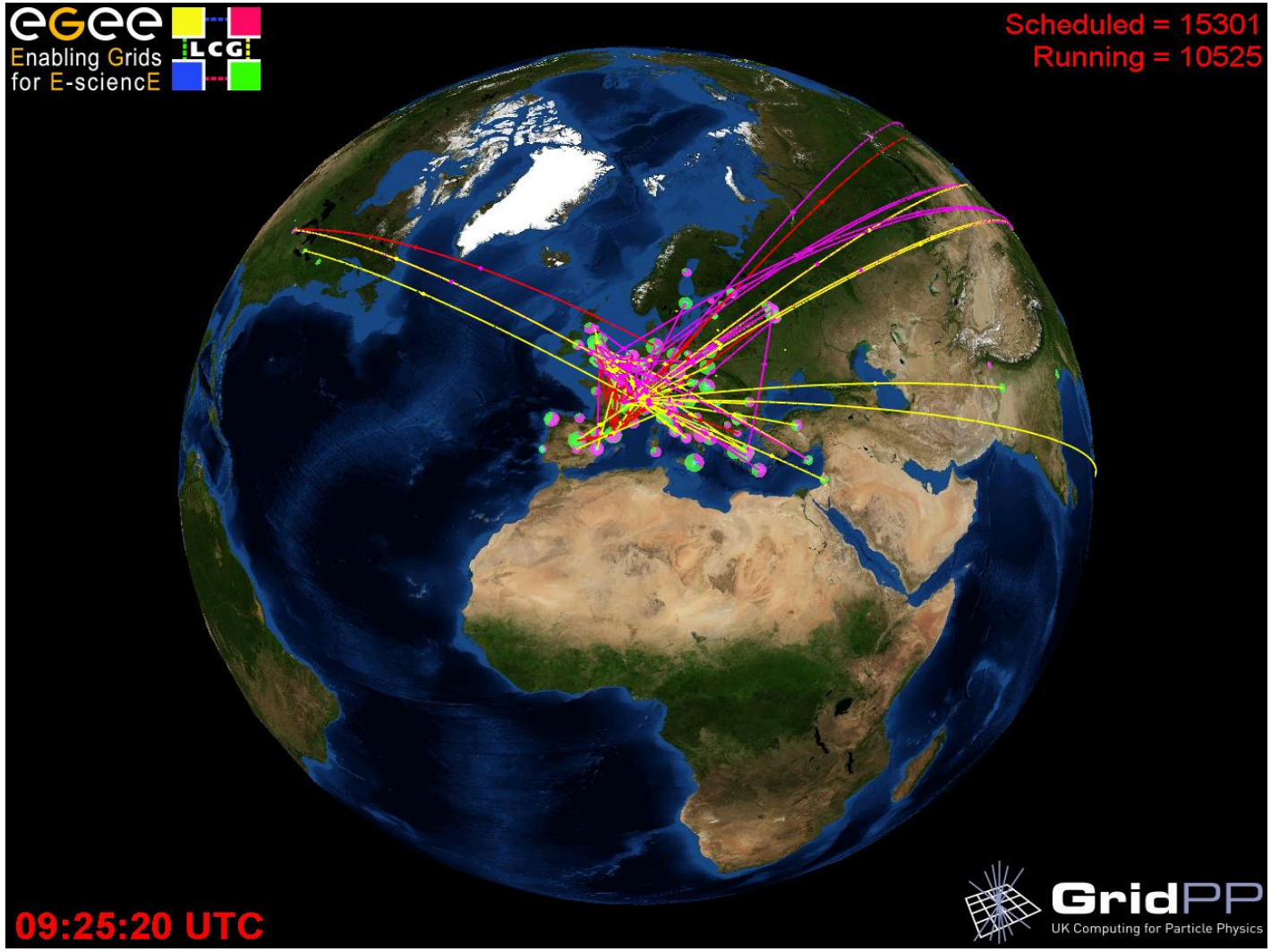
2017: 40 PB
ALICE: 4.5 PB
ATLAS: 18 PB
CMS: 11.6 PB
LHCb: 5.6 PB



220 PB on tape
550 M files



World computing infrastructure



Computing for experimental physics

1 Tier1:

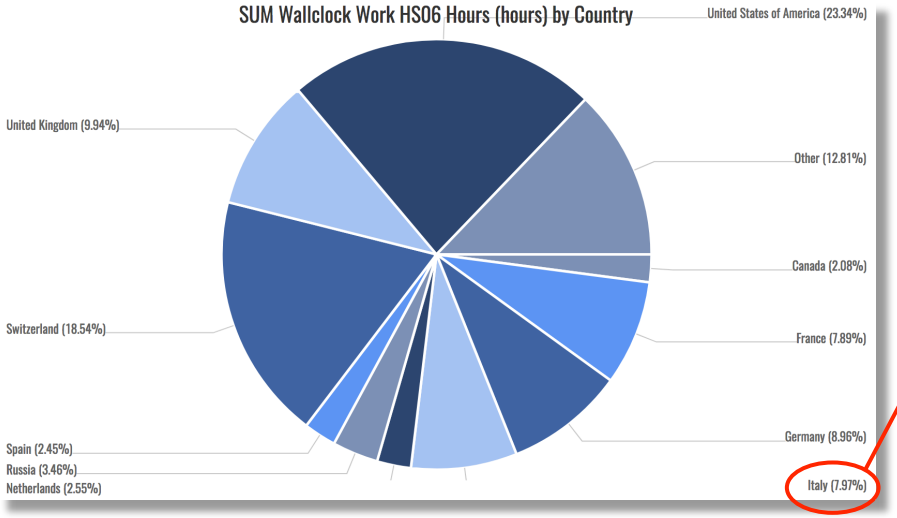
- 390 kHS06 CPU power equivalent to 40000 cores
- 40 PB disk space
- 65 PB tape library

9 Tier2:

- 240 kHS06 CPU power equivalent to 24000 cores
- 18 PB disk space

Network provided by GARR Consortium (10-100 Gbps) → upgrade

Resources distribution

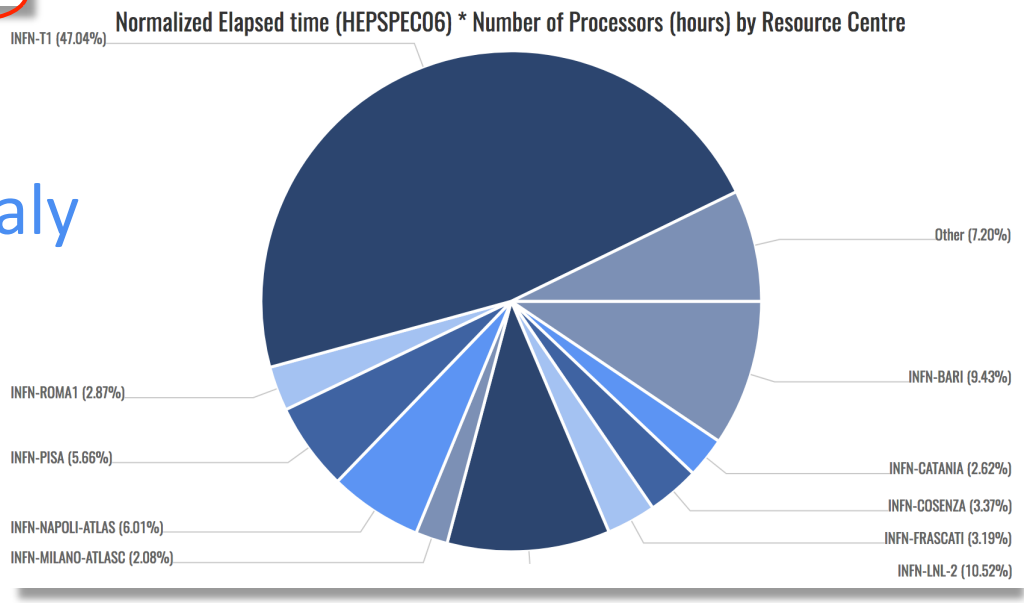


Italian contribution 8%

In the world → WLCG

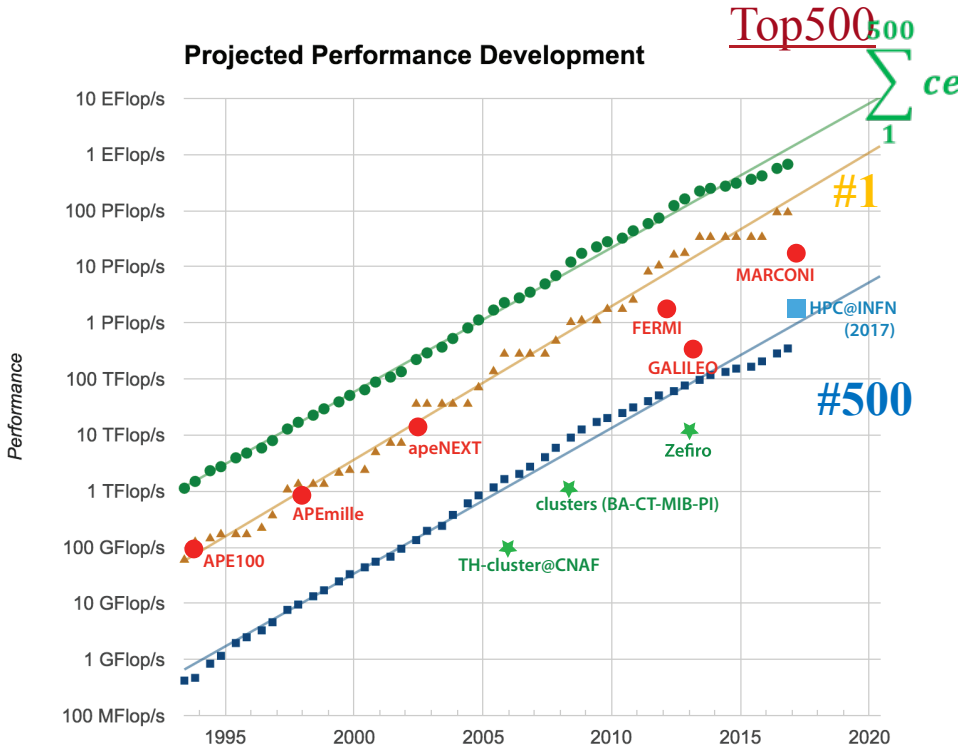
Half of the resources @ Tier1

In Italy



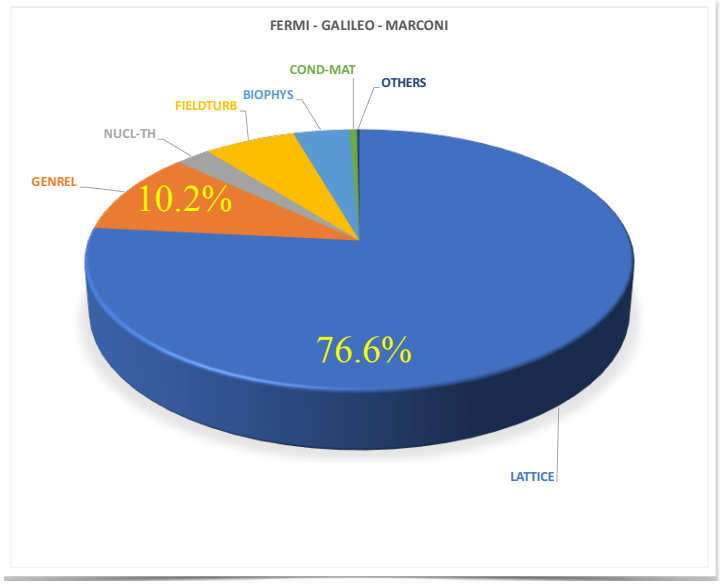
Very effective infrastructure for LHC data analysis !

Computing for theoretical physics



Currently exploiting CINECA, the national HPC computing center.

Use of INFN resources @ CINECA from 2012



Agreement INFN − CINECA valid for 3 years:
use of 6% MARCONI + 15 Mcorehours
GALILEO (~1.4 Pflops)

Costs & manpower

Budget

Item	Cost (M€)
CPU, disk and tape	4
HPC@CINECA	0.5
Electric power	2
Network(@GARR)	5
Total/year	11.5

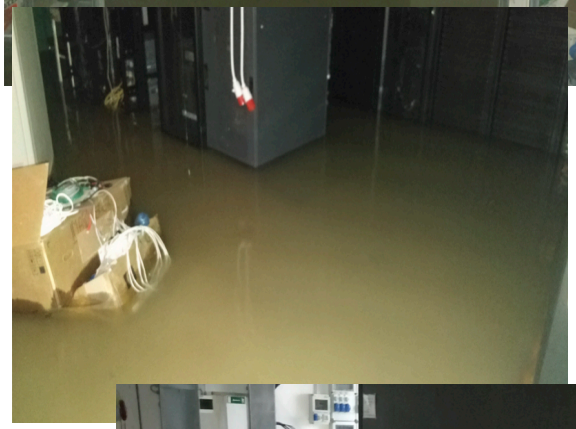
Personnel

Infrastructure	Middleware and software
50 FTE	30 FTE

External funds

Anno	Tipo	Progetto	Budget Totale (M€)	Budget INFN (M€)
2015	H2020	INDIGO-DataCloud	11.1	2.1
2015	FISR	High performance data network	12.5	12.5
2016	H2020	ExaNeSt	8	0.7
2017	H2020	EOSCpilot	10	0.3
2017	H2020	EOSC-HUB	30	1.8
2017	H2020	Extreme DataCloud	3.1	0.6
2017	H2020	Deep Hybrid DataCloud	3	0.4
2017	H2020	EuroEXA	20	0.7
2018	H2020	Escape	16	0.9
2018	MIUR Comma 140	Trasferimento Tier1 e CINECA	15	15
2018	MIUR	PON IBISCO	18.7	11.9
			147.4	46.9

Unforeseen: CNAF Flood



- Nov 9, water main burst and flooded CNAF Tier 1
  - Damage to electrical equipment, lower parts of equipment racks, and tape library
  - Loss of 15% CPU farm, 136 tapes damaged
- CNAF was down until ~ Feb 2018
- Luckily not during data taking
- Tapes recovered by specialist company
- Tier 1 now back in production with full resources for 2018

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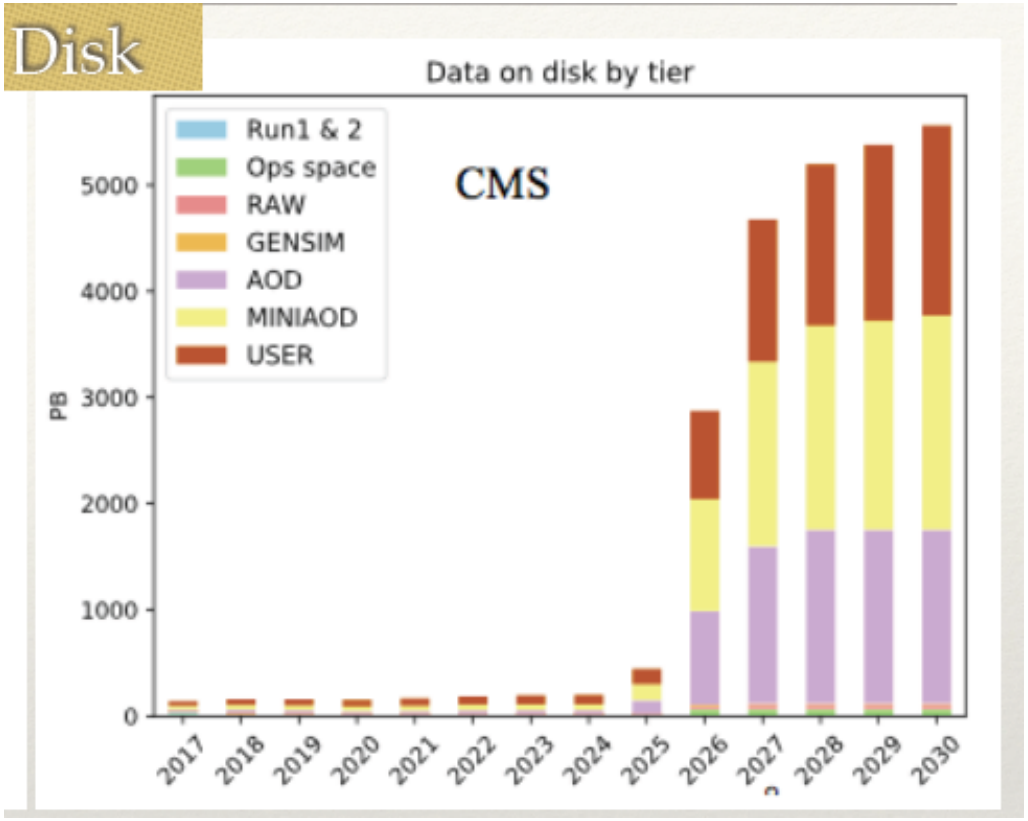
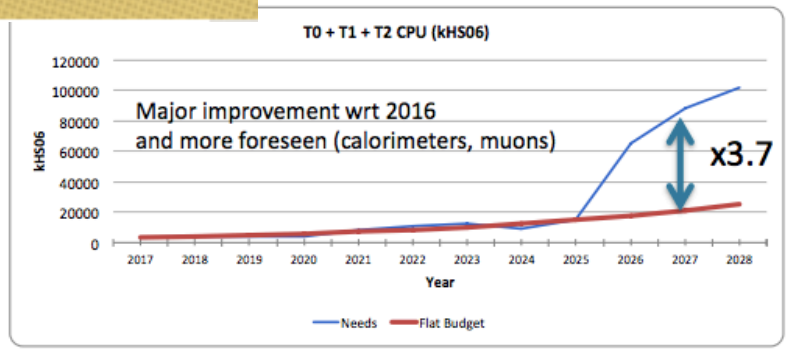
Future needs

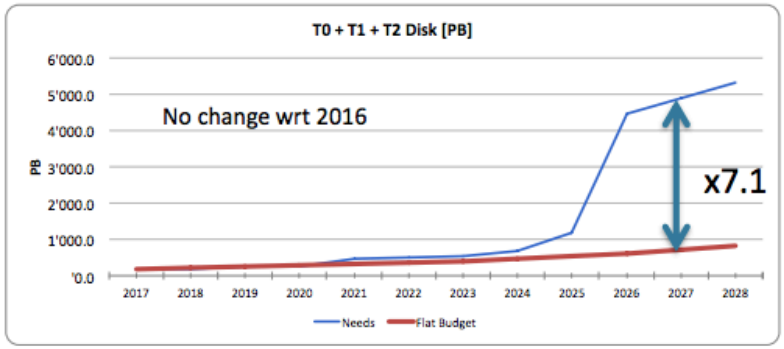
LHC resources for High-Lumi

Disk



CPU

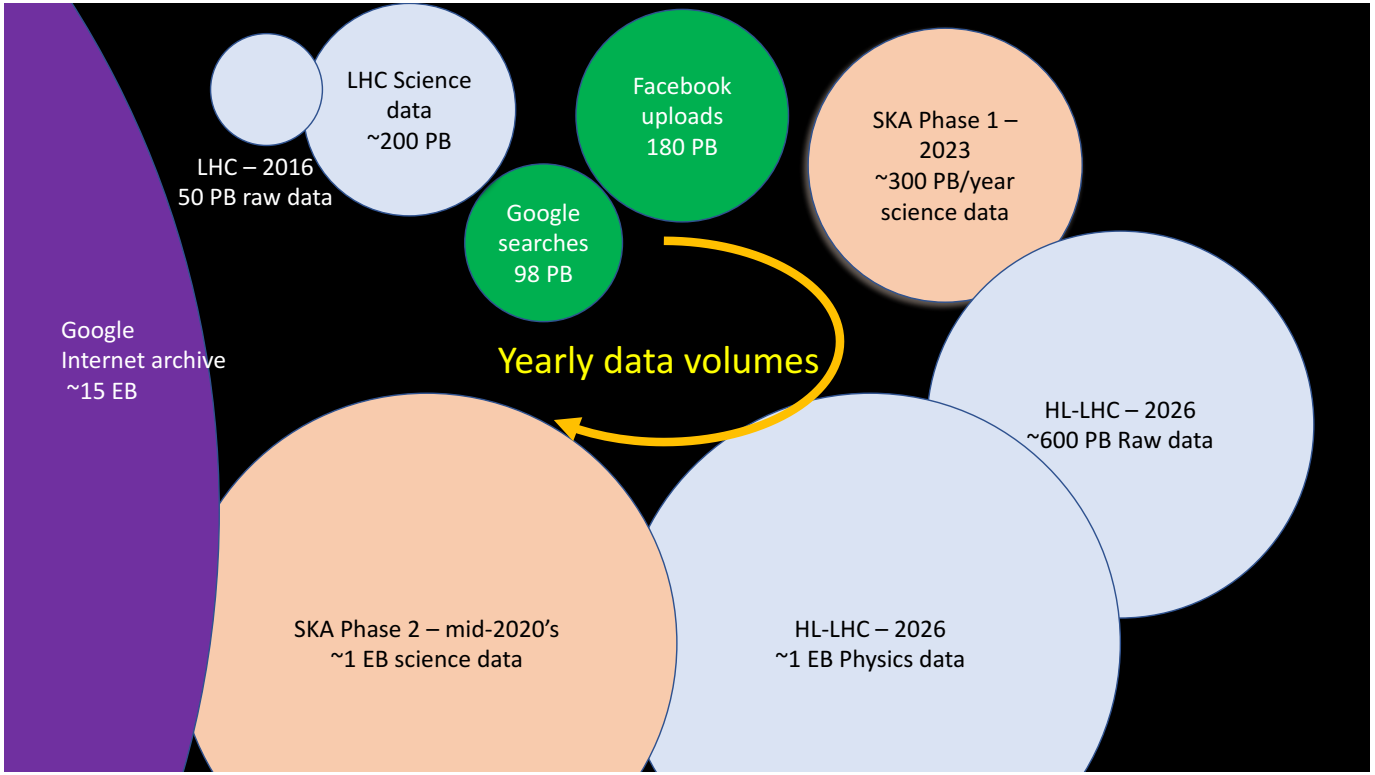




Disk space: 4x (CMS) e 7x(ATLAS)

CPU: 6x (CMS) e 4x (ATLAS)

Future Computing Resources

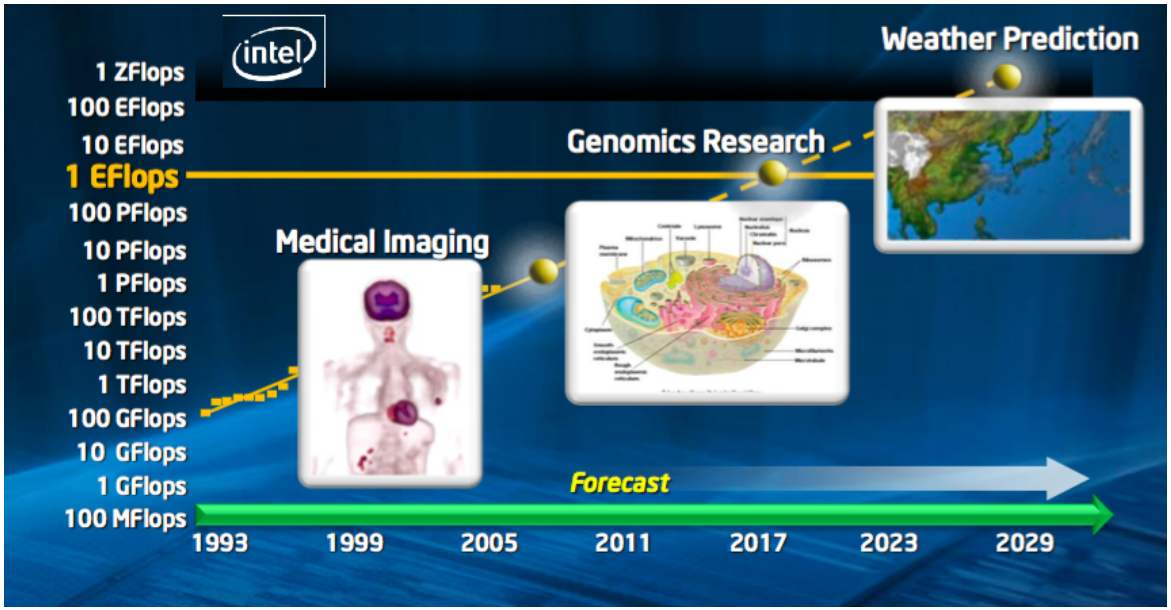


Future Astroparticle experiments (SKA, CTA, Euclid, …) will produce unprecedented amount of data.

Future Computing Resources

Huge resources demand resulting in requests of HPC and Big Data management will come from many different research fields in the next years:

- HEP and astroparticle physics
- Human brain
- Biology
- Personalized medicine & genomics
- Weather predictions
- Climate change studies
- Material studies
- Smart manufacturing & Industry 4.0
- IoT
- SmartCities



Impact on private sector

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Future strategy

Action themes:

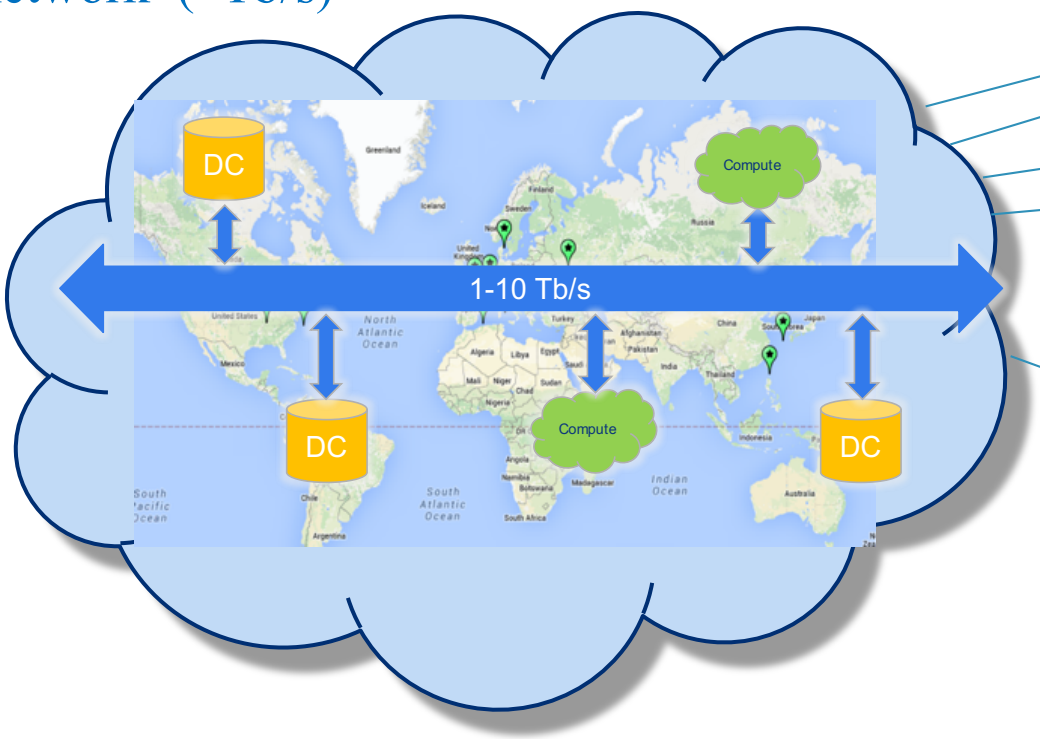
- SW performances & algorithmic optimization
- Middleware evolution toward cloud
- E-infrastructure evolution
  - → new location for the Tier-1
  - → Tier-2 optimization
- Exploitation of available resources
  - → HPC & commercial resources
  - → Integration of HTC and HPC infrastructure

The datalake

WLCG proposal

Computing Centers, withCPU and disk space

Fast network (~Tb/s)



Cloud access for Users

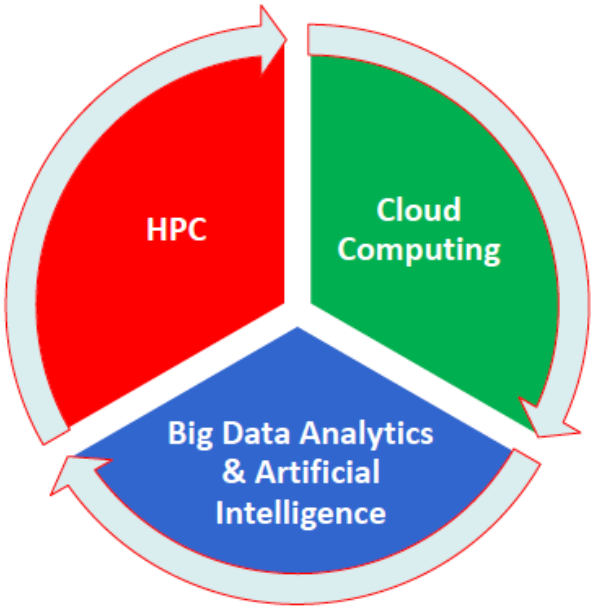
Commercial Clouds and HPC centers when available (elastic model)

Data Centers (DC): host the major part of tape and disk space with small CPU (core of the infrastructure)

European context

- In 2015 launch of the European Open Science Cloud (EOSC) initiative to provide an e-infrastructure for all European research communities.
- In 2016 signature of the EuroHPC agreement to provide a 10 years European strategy toward HPC exascale machines

Build a world-class European HPC, Big Data and Cloud Ecosystem



EuroHPC initiative

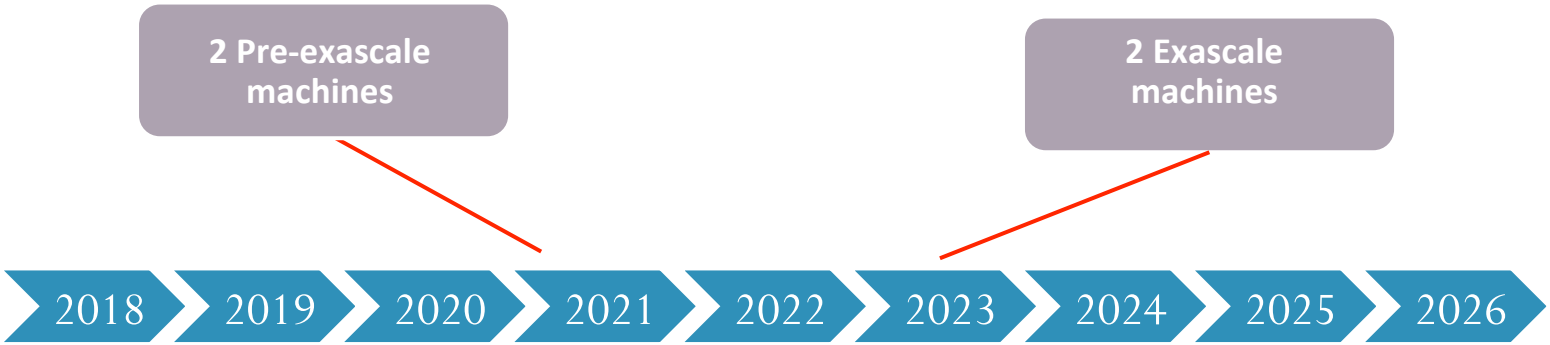
Declaration signed in Rome 23/03/2017 by:

For Italy signed the Ministries of Education University and Research and of Economic Development

- **to provide scientists, industry and the public sector from the Union with latest HPC and Data Infrastructure** to provide a framework for **acquisition of an integrated world-class pre-exascale supercomputing** and data infrastructure in the Union;

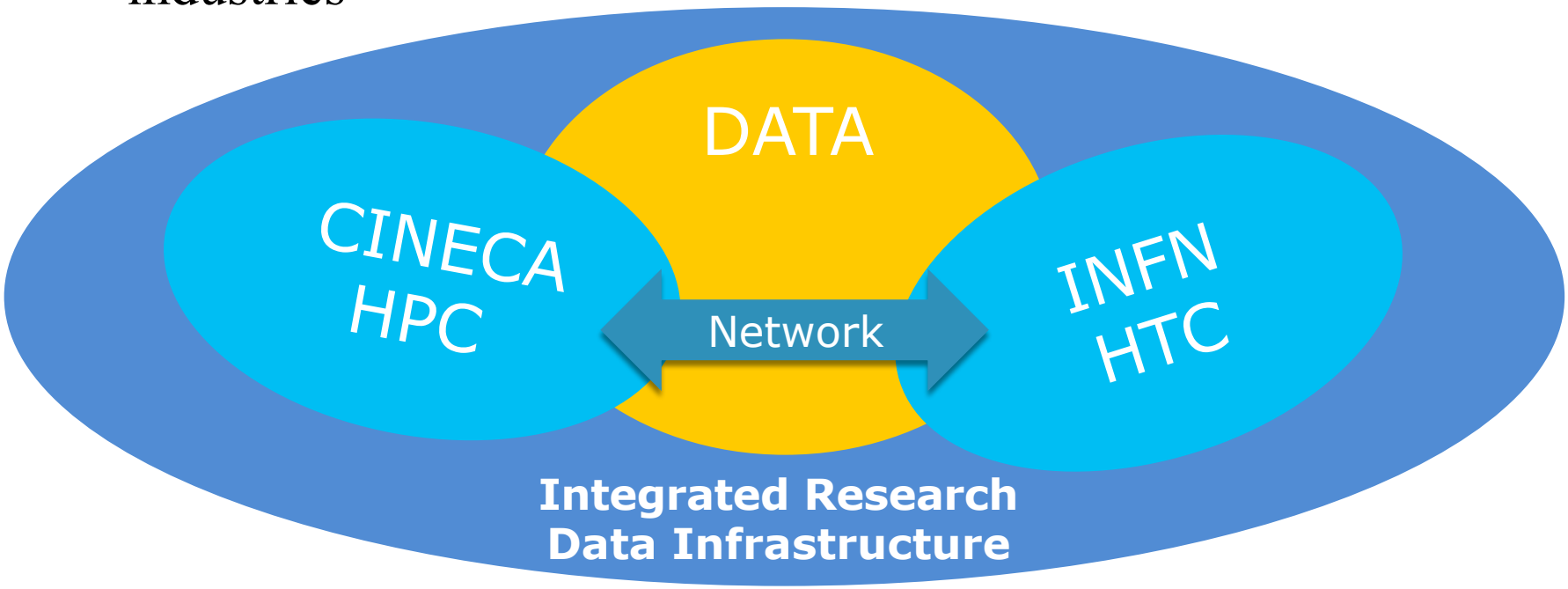
Present EU Financial Framework

Next EU Financial Framework

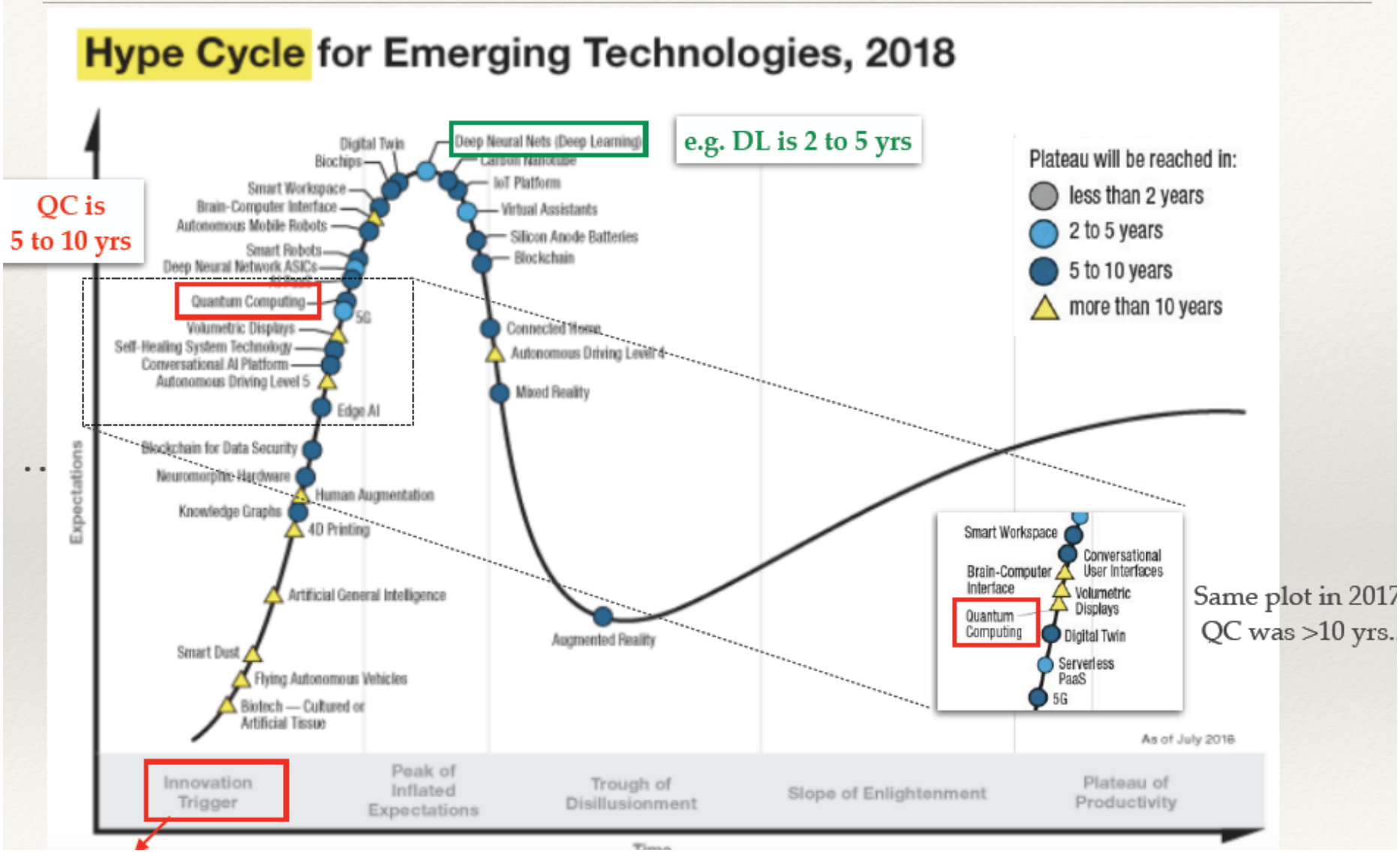


HTC and HPC infrastructure Integration

- INFN started a project with CINECA in order to integrate them to provide services to:
  - Institutional basic and applied research
  - Proof of concept and innovation for private organizations and industries



Long term future



Same plot in 2017
QC was >10 yrs.

Bologna Big Data Technopole

Bologna Big Data Technopole – Bologna Hub

A National and Regional investment for Digital Economy and BD

POR FESR EMILIA-ROMAGNA 2014/2020

POR FSE 2014-2020 ER Educazione Ricerca Emilia-Romagna

UNIONE EUROPEA
Fondi strutturali e di investimento europei

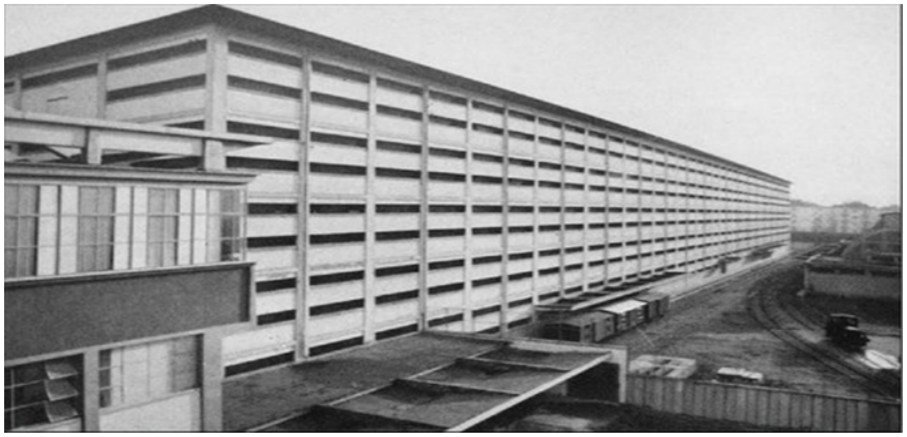
Regione Emilia-Romagna

ASTER
innovazione attiva

Bologna Big Data Technopole – Bologna Hub History

Designed in 1952 by Pier Luigi Nervi (1891 – 1979) for the Italian State Tobacco Monopoly, Bologna, Manifattura is a masterpiece of XX century industrial architecture

Closed in 2004, after a period of abandon, the complex of about 100.000 sqm was acquired by the Emilia-Romagna Region. In 2016 it was devoted to host the Bologna Big Data Technopole



Bologna Big Data Technopole – Bologna Hub

This building with one big vault was the salt and tobacco deposit, for this reason it is called **«Magazzino del sale»** (Salt warehouse))

In these buildings there were the special works and therefore now is called **«Speciali»**

This five-story building is called **«Le ballette»** because the bales of tobacco were stored here before being processed.

This large building is called **«Le botti»** (the barrels), under its barrel vaults there was the processing of tobacco

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RegioneEmilia-Romagna
ASTER innovazione attiva

Bologna Big Data Technopole – Bologna Hub – the future

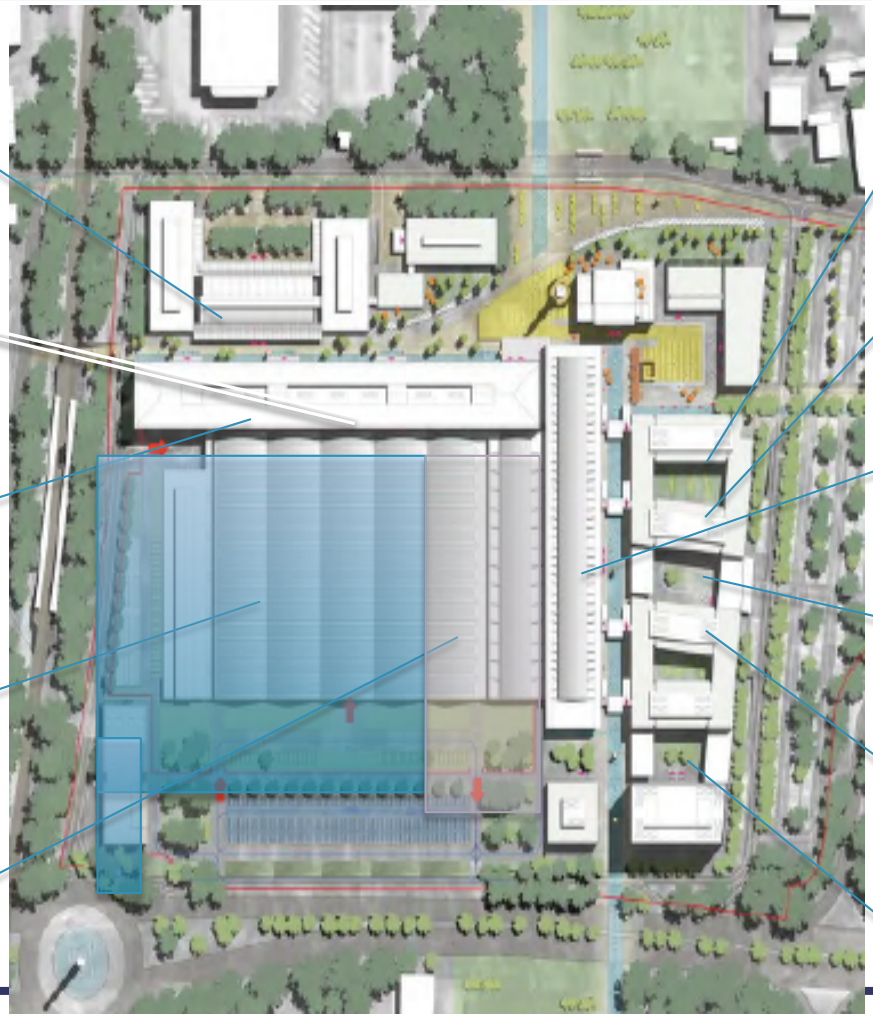
Conference and Education centre

BIG DATA for science & humanities FOUNDATION

«Ballette research and innovation centre»

ECMWF Data centre

CINECA-INFN Supercomputing centre



Competence centre Industry 4.0 BI-REX

Protezione civile and regional agency for development and innovation

Enea centre

IOR biobanks

University centres

National Agency Italia Meteo

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POR FSE 2014-2020 ER Educazione Ricerca Emilia-Romagna

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RegioneEmilia-Romagna

ASTER innovazione attiva

The data centers at the Science Park

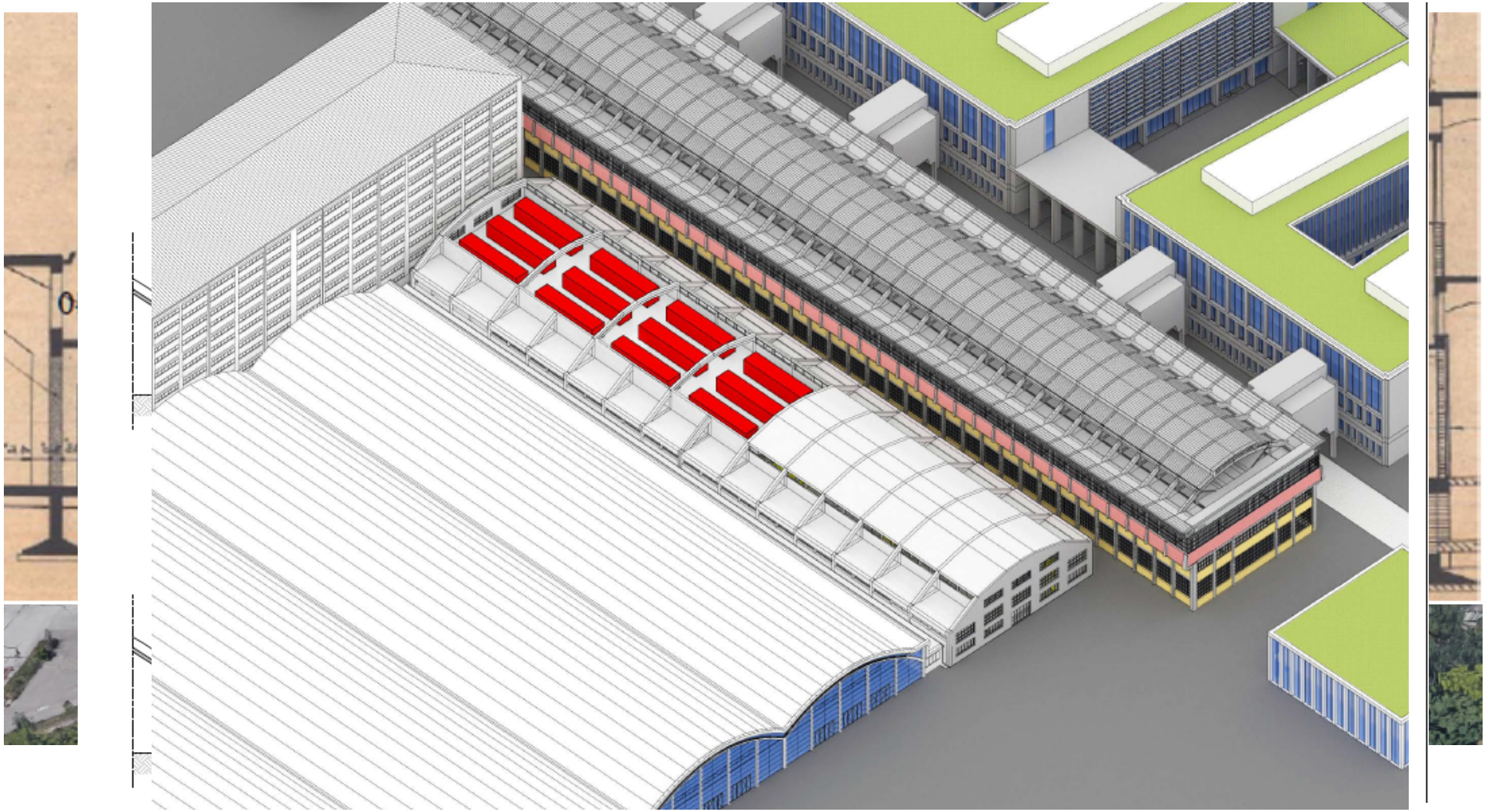
ECMWF DC main characteristics

- 2 power line up to 10 MW (one bck up of the other)
- Expansion to 20 MW
- Photovoltaic cells on the roofs (500 MWh/year)
- Redundancy N+1 (mechanics and electrical)
- Cooling
  - 4 dry coolers (1850 kW each)
  - 4 groundwater welles
  - 5 refrigerator units
- Peak PUE 1.35 / Maximum annualized PUE 1.18

INFN – CINECA DC main characteristics

- up to 20 MW (one bck up of the other)
- Possible use of Combined Heat and Power Fuel Cells Technology
- Redundancy strategy under study
- Cooling, still under study
  - dry coolers
  - groundwater welles
  - refrigerator units
- PUE < 1.2 – 1.3

Current status



Not only physics

Molte applicazioni pratiche per la nostra e-infrastructure:

- Medicina (genomica, ACC ....)
- Industria 4.0 (Competence centers ....)
- Dati da satellite e monitoraggio territorio (dati Copernicus – ASI/CNR/ INFN .....)
- etc. etc.


Grazie per
l'attenzione

Backup slides

Conclusions

- In the next years we have to cope with un unprecedented amount of data coming from many different fields (not only HEP)
- INFN e-infrastructure is in a transition phase
- We are actively exploring the most suitable solutions for our future

Toward a Cloud based system

Definition of the EOSC governance
Realization of demonstrators
PI:UK INFN: D. Salomoni

EOSC-hub

Data and sertvices for EOSC
PI: EGI INFN: L. Gaido

XDC
eXtreme DataCloud

Development of technologies for storage resources federation and for data management
PI: INFN D. Cesini

DEEP HybridDataCloud
Designing and Enabling E-Infrastructures for intensive Processing in a Hybrid DataCloud

Services and support for intensive computing for different disciplines
PI: CSIC (Spain) INFN: G. Donvito

INFN projects toward HPC exascale

European Exascale System Interconnection Network & Storage
PI: Foundation for Research & Technology, GR
INFN: P.Vicini

ExaNeSt

EuroEXA
Project ID: 754337

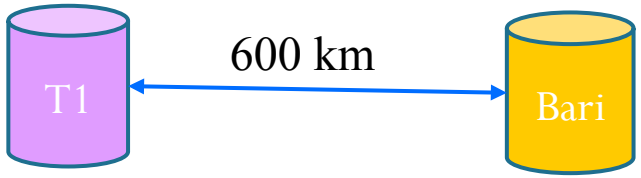
Co-designed Innovation and System for Resilient Exascale Computing in Europe: From Applications to Silicon
PI: Institute of communication and computer systems, GR
INFN: P. Vicini

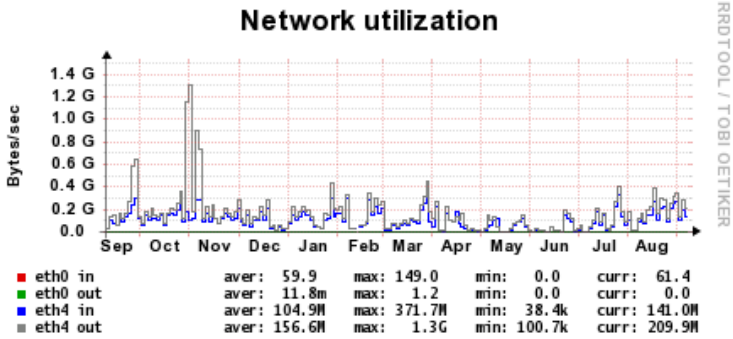
Progetto CIPE

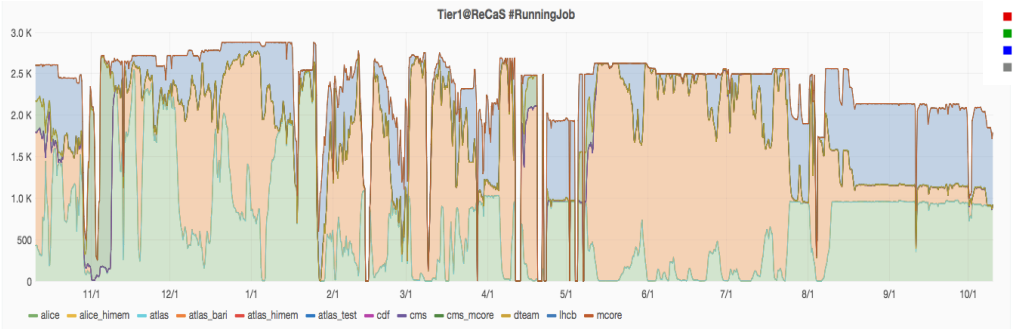
Acquisition and exploitation of many core "next gen" for INFN HPC e HTC infrastructures
P. Vicini et al.

Tests on flexible use of the INFN infrastructure

The goal: test a flexible use of the infrastructure by using remote resources at Tier-1, by using in a transparent way CPU at Tier-2 Recas in Bari







It is working···

Performed tests also on small scale with private cloud providers: ARUBA e AZURE (microsoft)

Theoretical physics HPC requests

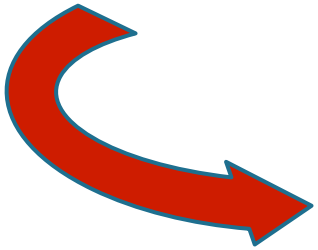
Computational theoretical physics at INFN: status and perspectives (2018-2020)

R. Alfieri, B. Alles, S. Arezzini, S. Bernuzzi, L. Biferale, G. Boffetta*, C. Bonati, G. Brancato, C.M. Carloni Calame, M. Caselle, P. Cea, A. Ciampa, M. Colpi, L. Cosmai*, L. Coraggio, G. de Divitiis, M. D'Elia*, R. De Pietri*, E. De Santis, C. Destri, G. Di Carlo, P. Dimopoulos, F. Di Renzo, A. Drago*, P. Faccioli, R. Frezzotti*, A. Gamba, A. Gargano, B. Giacomazzo, L. Giusti*, G. Gonnella, N. Itaco*, A. Kievsky, G. La Penna, A. Lanotte*, W. Leidemann, M. Liguori*, M.P. Lombardo*, A. Lovato, V. Lubicz, L.E. Marcucci, E. Marinari, G. Martinelli*, A. Mazzino, E. Meggiolaro, V. Minicozzi, S. Morante*, P. Natoli*, F. Negro, M. Nicodemi*, P. Olla, G. Orlandini, M. Panero*, P.S. Paolucci*, A. Papa*, G. Parisi*, F. Pederiva*, A. Pelissetto, M. Pepe, F. Piccinini*, F. Rapuano, G.C. Rossi, G. Salina, F. Sanfilippo, S.F. Schifano*, R. Schneider, S. Simula*, A. Sindona*, F. Stellato, N. Tantalo, C. Tarantino, G. Tiana, R. Tripiccione*, P. Vicini*, M. Viel, M. Viviani*, T. Vladikas, M. Zamparo

* *Conveners*

(Dated: April 26, 2017)

We present the status of computational theoretical physics at INFN, the results obtained by its research groups active in this field and their research programs for the next three years. Computational theoretical physics, besides its own importance, is a powerful tool in understanding present and future experiments. A continued support of INFN to computational theoretical physics is crucial to remain competitive in this sector. We assess the high performance computing resources needed to undertake the research programs outlined for the next three years.



Requested resources

	2018	2019	2020
LGT: hadron physics	54	108	180
LGT: QGP and BSM	207	432	648
LGT: flavor physics	117	234	387
Colliders Phenomenology	1	2	3
General Relativity	142	182	227
Cosmology and Astroparticle Physics	3	4	6
Nuclear Theory	18	27	36
Fluid Dynamics	50	80	110
Quantitative Biology	9	18	27
Disordered systems	4	6	8
Condensed matter	2	4	6
Grand Total (Mcore-h)	**607**	**1097**	**1638**
Grand Total (Eq. Pflops)	**4.6**	**8.4**	**12.5**

INDIGO - DataCloud
Better Software for Better Science

D. Salomoni

Downloads from INDIGO Repository

ELECTRICINDIGO supports:

- Operative Systems: CentOS 7, Ubuntu 16.04
- Cloud environment: OpenStack Newton, OpenNebula 5.x (links with Amazon, Azure, Google)

ELECTRICINDIGO provides:

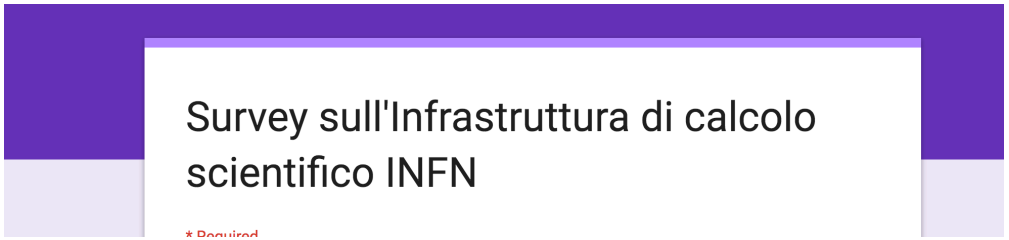
- Interfaces for Cloud providers
- Authentication and Authorization systems
- Data Management and Analytics
- Portals and solutions for mobile telephones
- Services for data centers e providers

INFN Computing Organization

- 1 National Computing Center (CNAF in Bologna) hosting the WLCG Tier-1, where is concentrated the major part of the personnel
- 9 Tier-2 centers on the Italian territory sitting mainly in University Physics Departments
- C3S “Comitato di Coordinamento attività Calcolo Scientifico INFN”. Mandate: make proposals for research and developments for scientific computing, including the development of a shared computing infrastructure, to support researchers primarily from INFN, but also from different research institutions.

Optimization of the INFN e-infrastructure for HEP and other disciplines

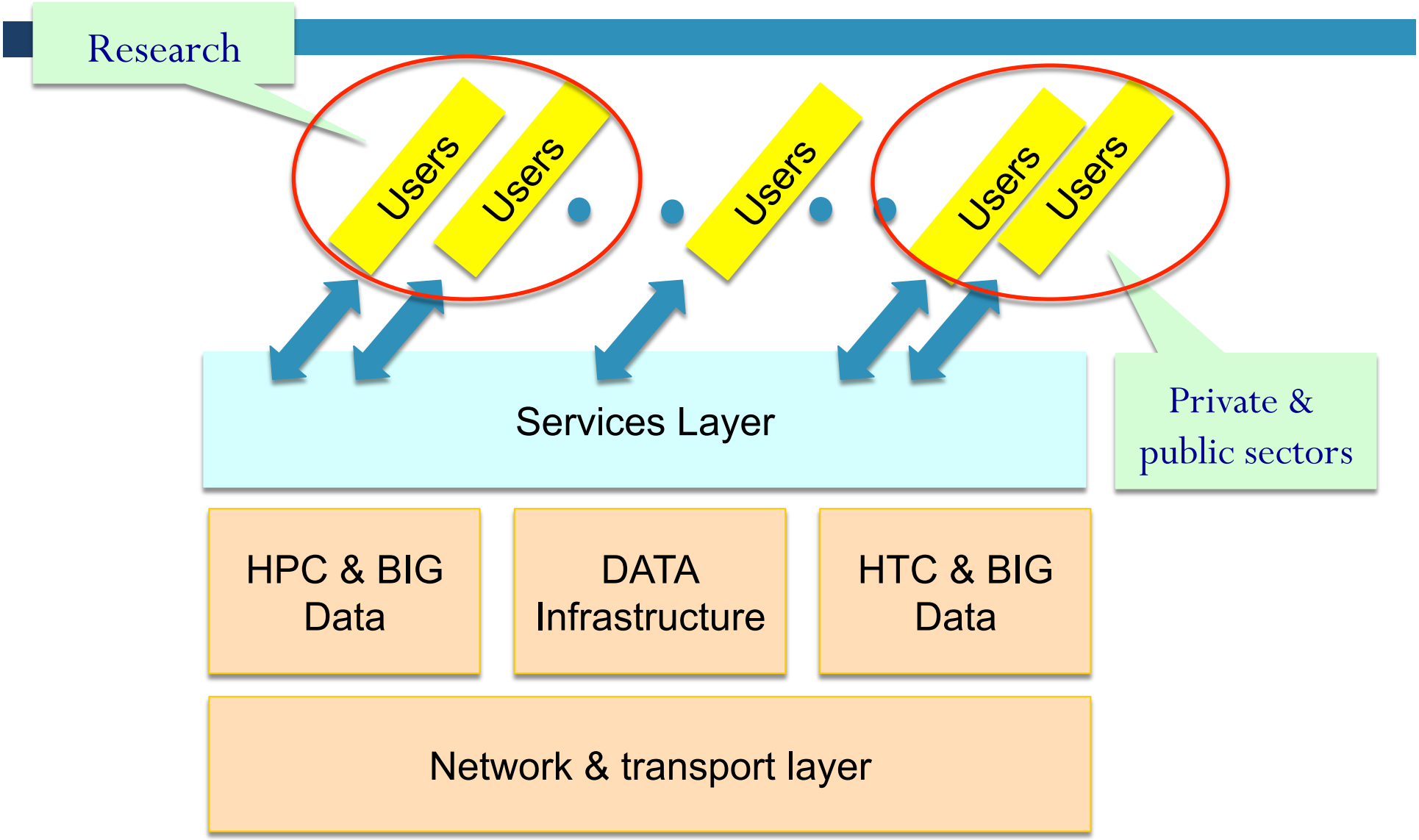
- INFN started a survey of its computing infrastructure in order to evaluate the status, the sustainability and the evolution



30 e-Infrastructures	
Big (T1+T2+CS+TS)	Small
10	20
95% Resources	5% Resources

- INFN signed a MOU started a collaboration with INAF to expand and exploit a common infrastructure. First action is hosting data and provide computing resources to the CTA experiment
- INFN started a collaboration with ASI to host data of the Copernicus and CosmoSkyMed satellites and to provide computing resources to the relevant interested communities

Implementation model



Current status

- 1 Tbps network between CINECA and CNAF already in operation
- Integration between the two centers already started. Some CINECA machine currently used from HTC infrastructure
- Development of CLOUD tools ongoing
- Defined some projects with private involvement to exploit HPC and HTC resources about Industry 4.0, smart-mobility, personalized medicine, smart-grid , materials… (H2020, and regional funds)