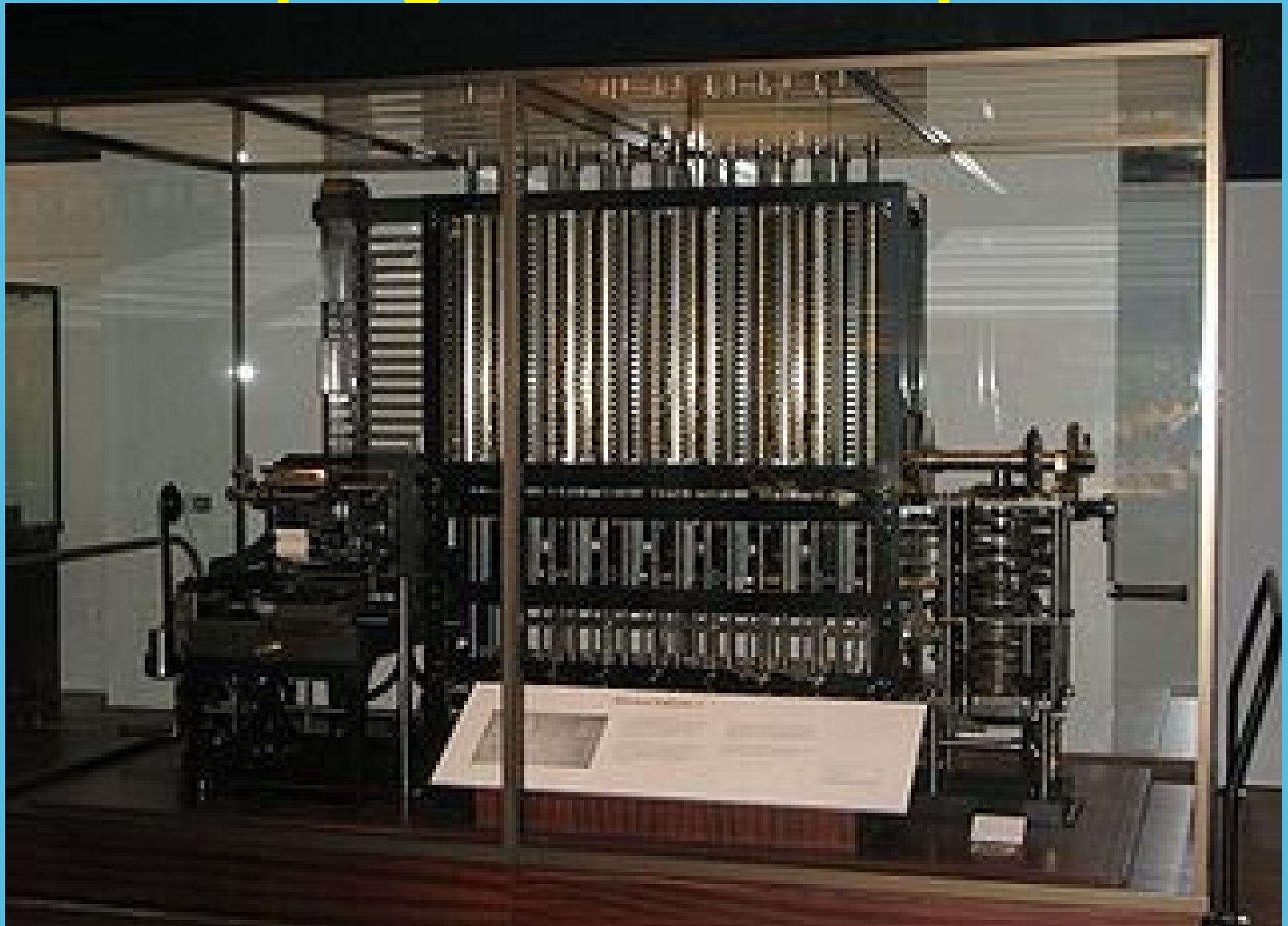


Course: Cluster, Grid, Cloud computing systems

Introduction lecture

- History of computing
- Demands for computing
 - Science, techniques, education, business, government
- **Large scale computing**
 - Equipment, programs
 - Grid and Cloud computing
 - Computing in Physics experiments
- **Scientific large scale computing**

First programmed computer



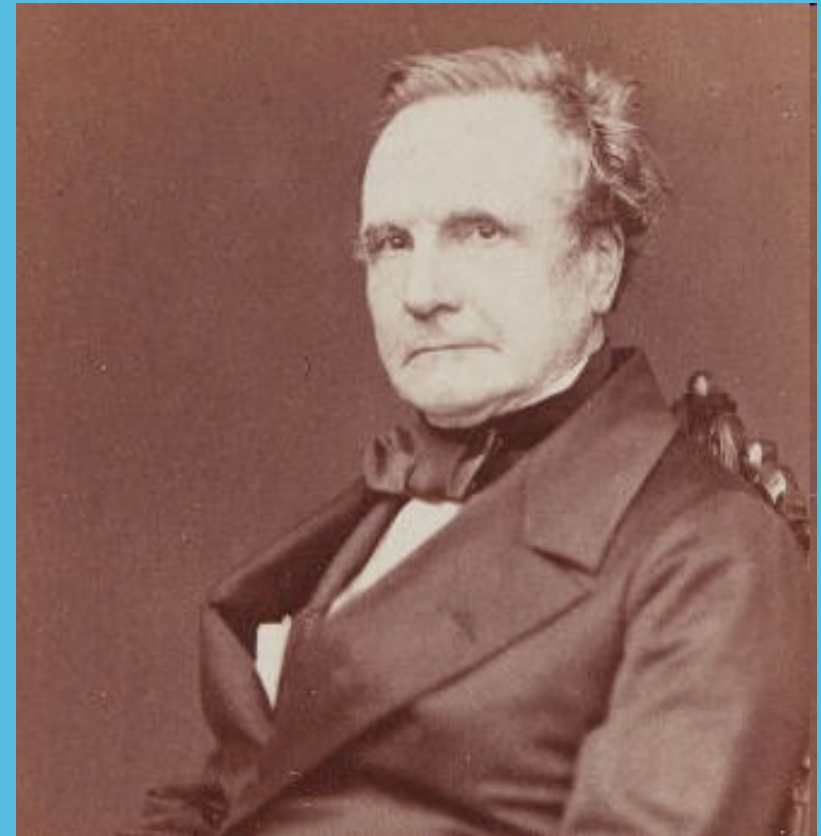
Charles Babbage (1791 - 1871) –
Inventor of first programmed computer



Ada Lovelace (Byron)

1815 - 1852

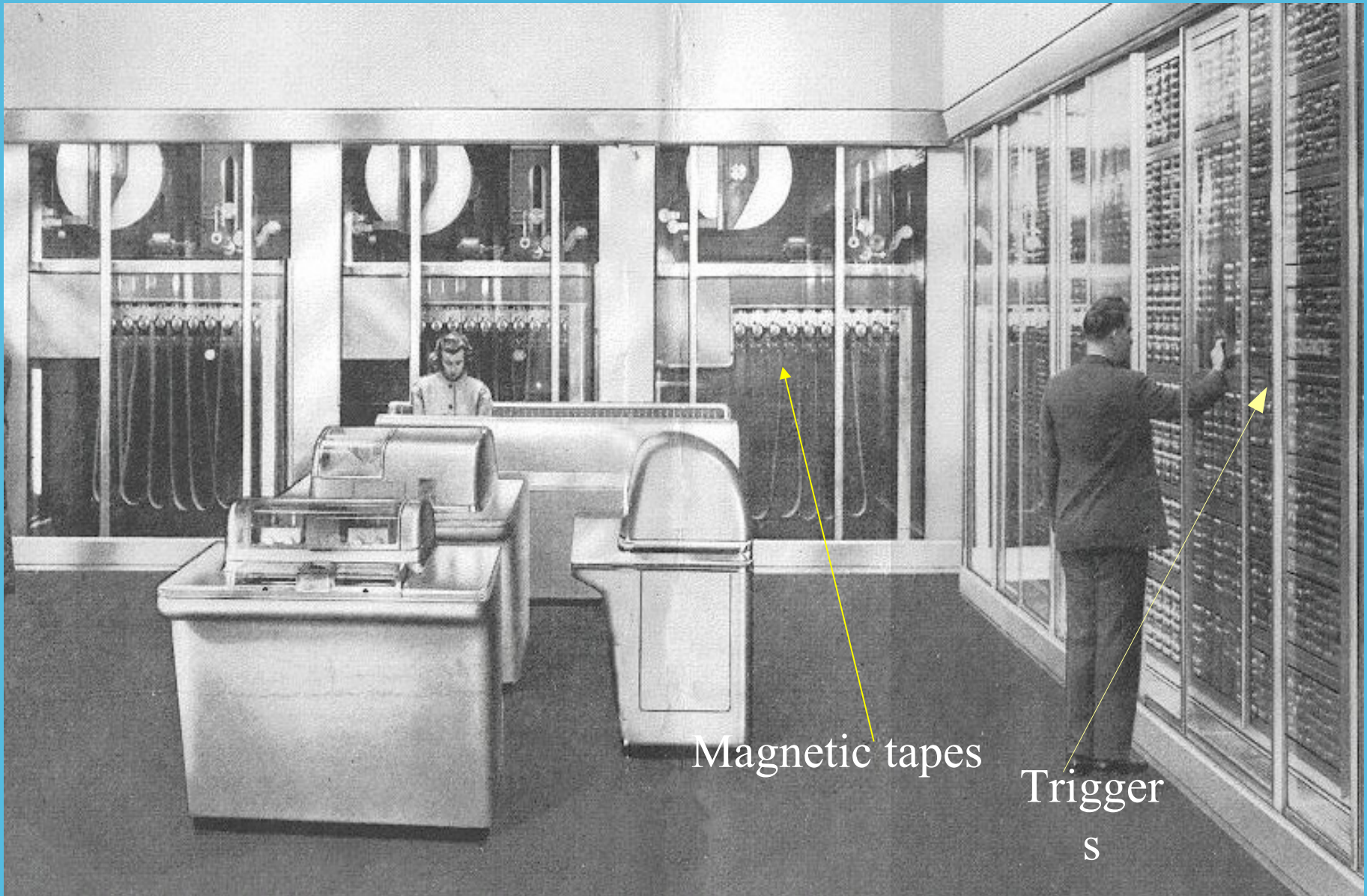
first programmer in the world





She (Ada) speculated that the Engine 'might act upon other things besides numbers... the Engine might compose elaborate and scientific pieces of music of any degree of complexity or extent'.

First electronic: Electronic Numerical Integrator And Computer (~1943)



Modern computing systems

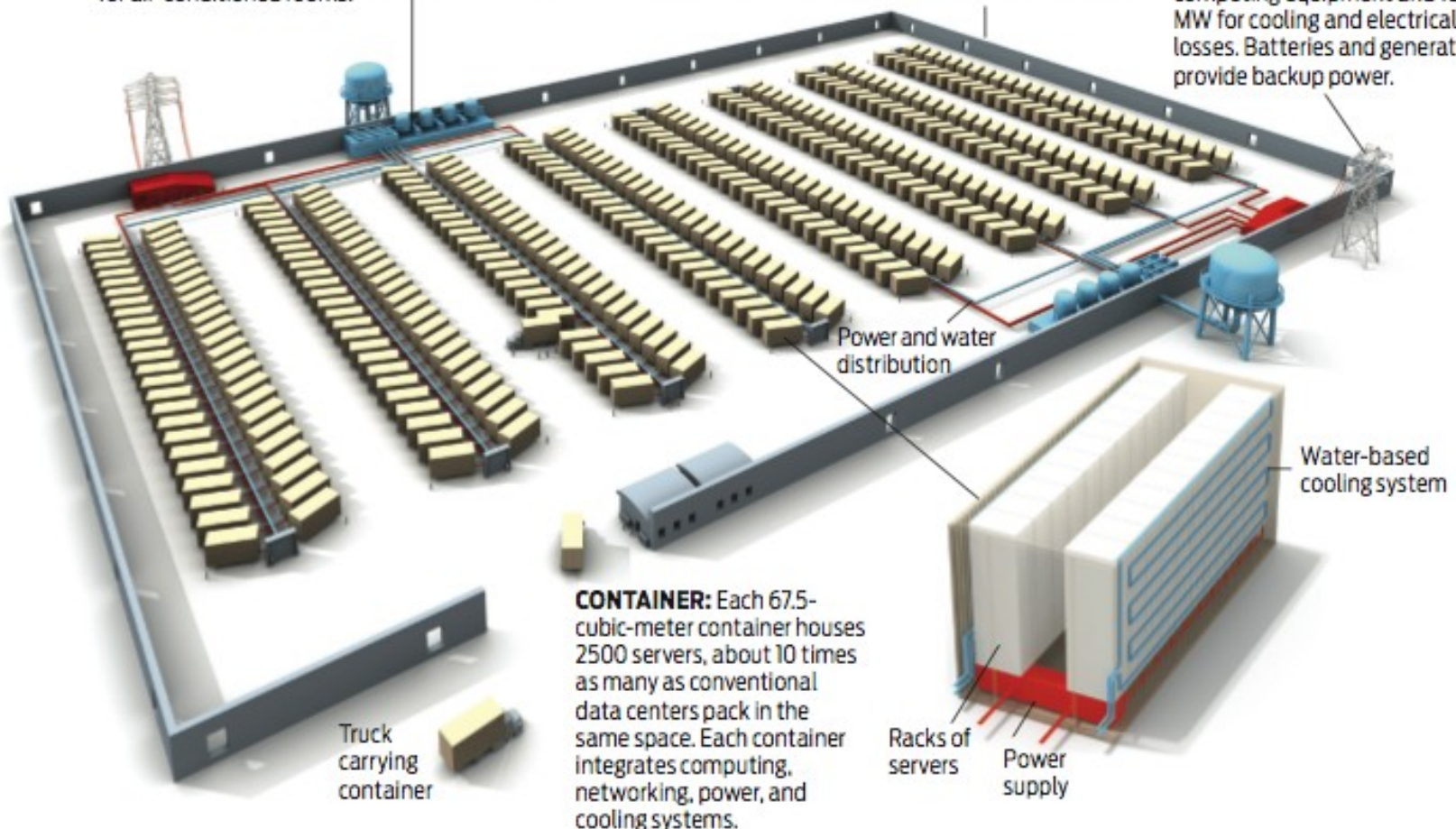
The main feature is using the heterogeneous architectures (servers, accelerators: GPGPU - General-Purpose Computing on Graphics Processing Units, FPGA - field-programmable gate array) and Open Source Software.

Modern big cluster plan

COOLING: High-efficiency water-based cooling systems—less energy-intensive than traditional chillers—circulate cold water through the containers to remove heat, eliminating the need for air-conditioned rooms.

STRUCTURE: A 24 000-square-meter facility houses 400 containers. Delivered by trucks, the containers attach to a spine infrastructure that feeds network connectivity, power, and water. The data center has no conventional raised floors.

POWER: Two power substations feed a total of 300 megawatts to the data center, with 200 MW used for computing equipment and 100 MW for cooling and electrical losses. Batteries and generators provide backup power.



Large Data Centers



WAREHOUSE-SIZE COMPUTERS: Google has built a sprawling data center on the banks of the Columbia River, in The Dalles, Ore. The site, with two server-packed buildings and space for a third, houses tens of thousands of computers—the exact number is a closely guarded secret. Microsoft, Yahoo, and Amazon are also building data centers in the region, enticed by its readily available fiber-optic connectivity and cheap electricity. PHOTO: MELANIE CONNER

Google data center in Finland



Green clusters, large clusters

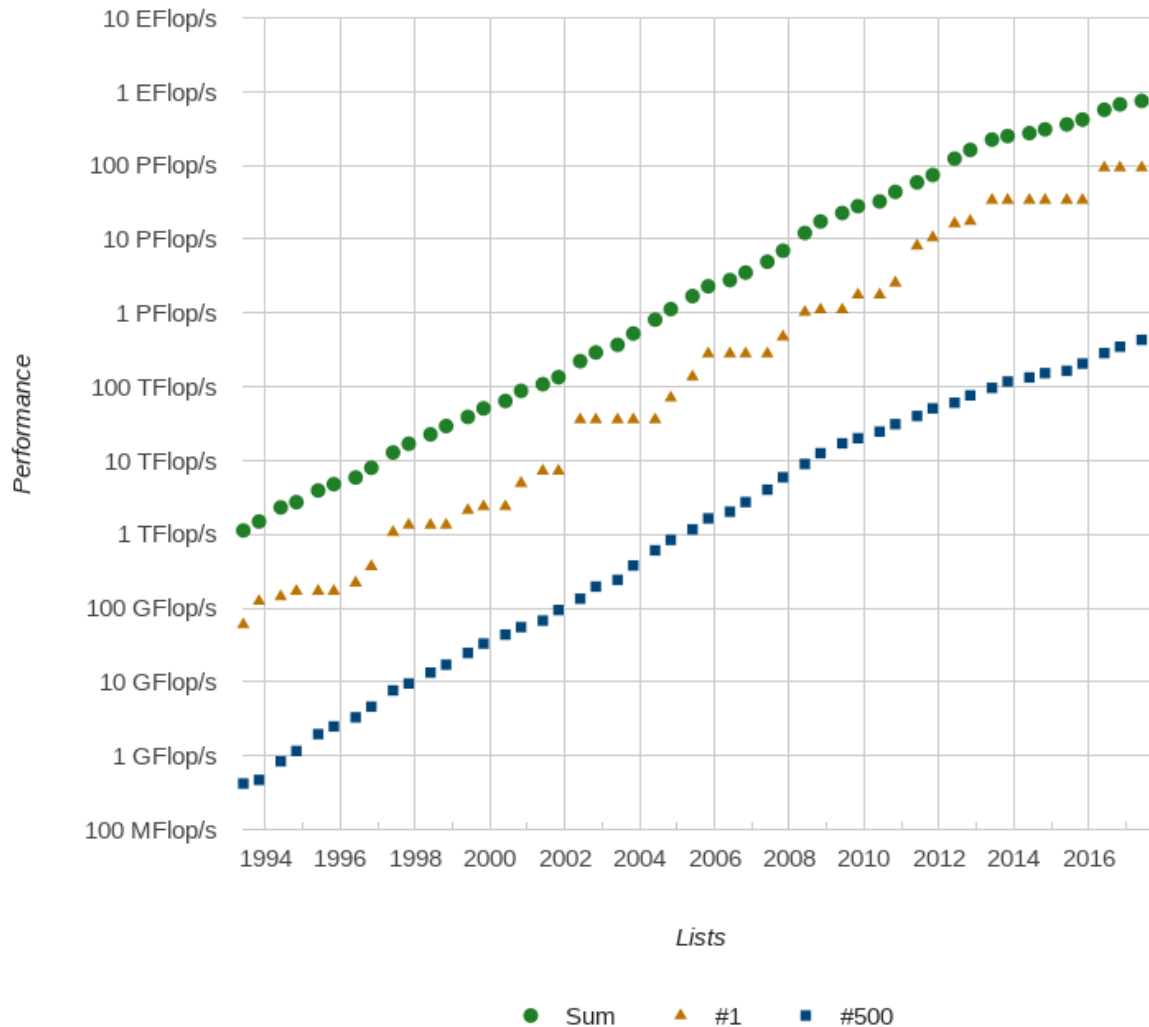
Green500.org – “greenest» clusters

Top500.org – largest clusters

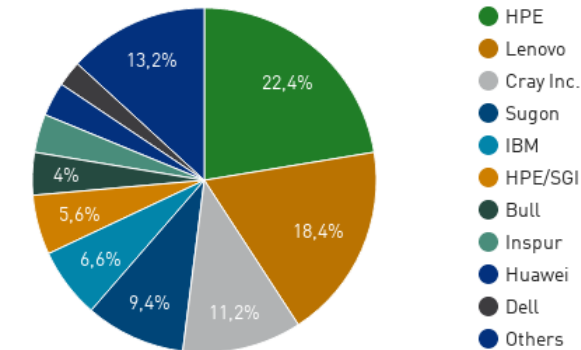
From site top500.org

Performance Development

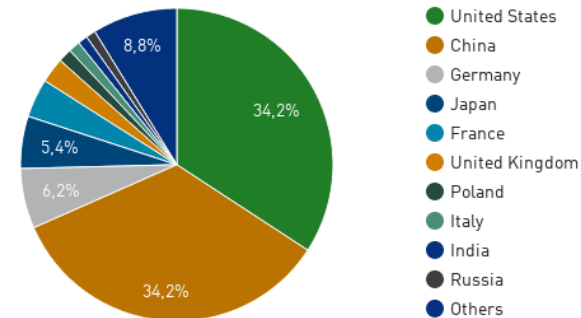
Nov 2017



Vendors System Share



Countries System Share

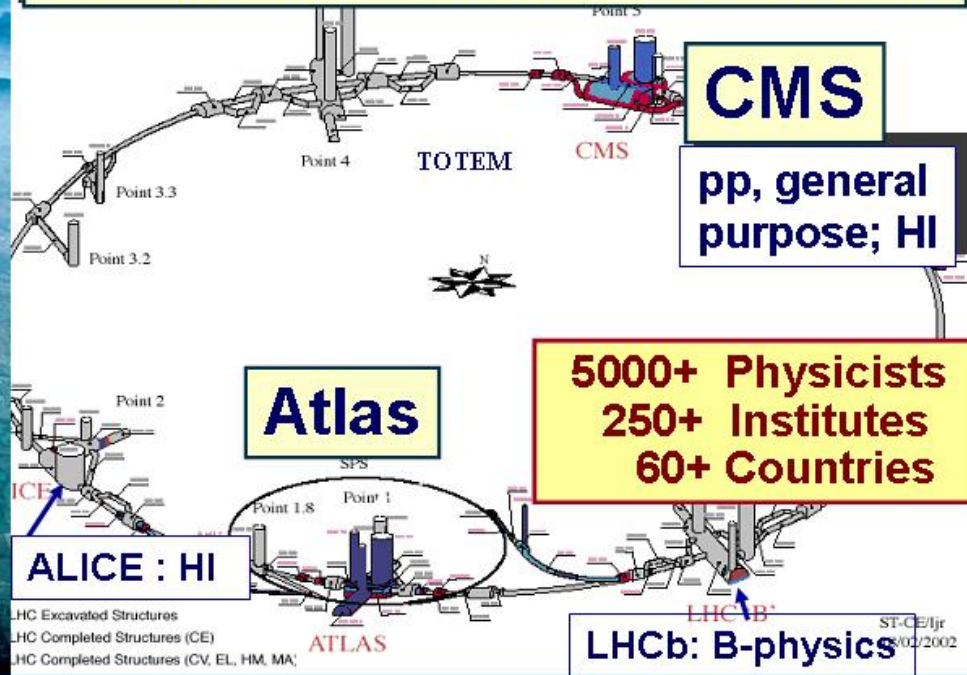




Large Hadron Collider CERN, Geneva: 2007 Start



* $pp \sqrt{s} = 14 \text{ TeV}$ $L = 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$
* 27 km Tunnel in Switzerland & France



**Challenges: Analyze petabytes of complex data cooperatively
Harness global computing, data & network resources**

View of the tunnel at LHC

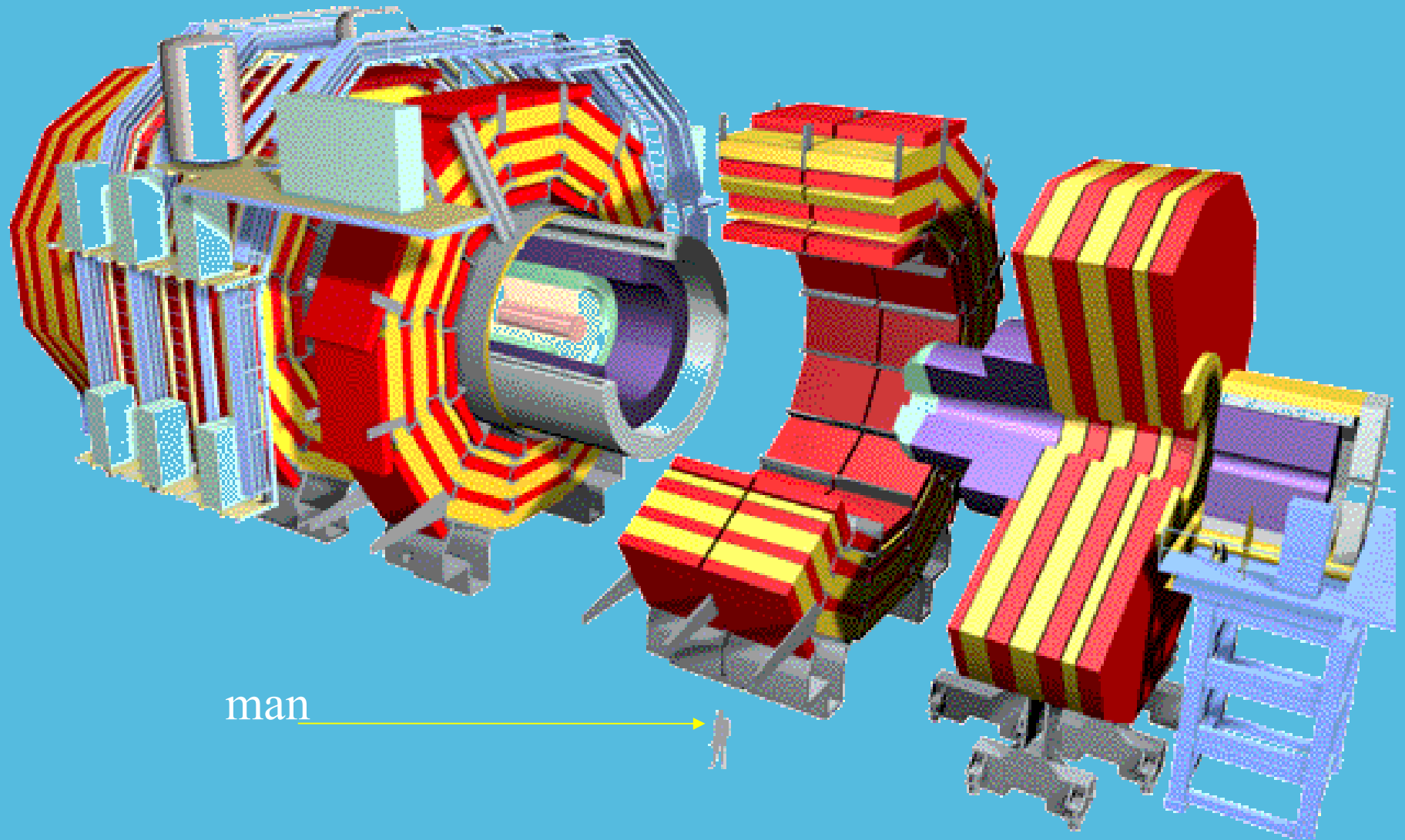
600 Million Proton Collisions/second

SC Magnets cooled to -193.2°C (80 K),
 -268.7°C (4.5K), -271.3°C (1.9k)
Using 10'000 tons of liquid
nitrogen and 120 tonnes of liquid helium

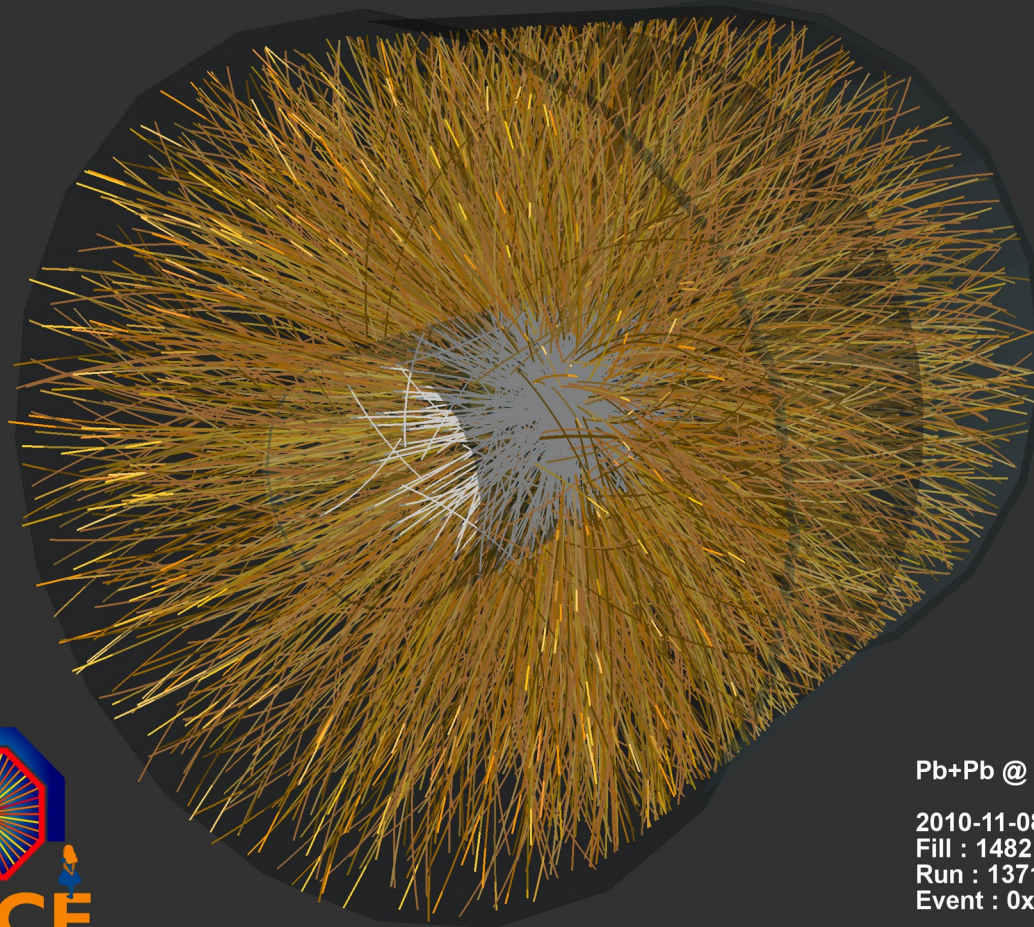
26659m in Circumference (but varies with the moon!)



Example of the detector size at LHC



Colliding of the particles



Pb+Pb @ $\sqrt{s} = 2.76$ ATeV

2010-11-08 11:29:52

Fill : 1482

Run : 137124

Event : 0x0000000042B1B693

DISUN: CMS Global Data Grid

CMS Experiment



CERN/Outside Resource Ratio ~1:4

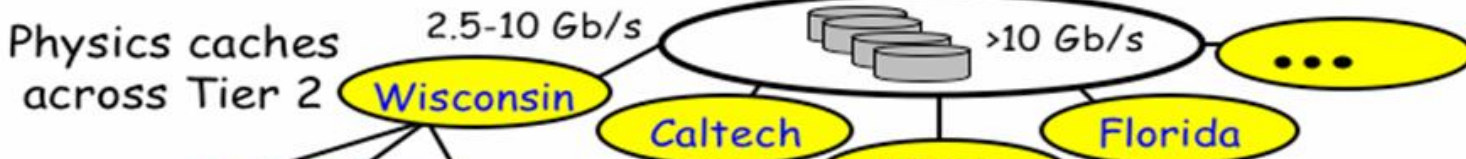
Tier0/(Σ Tier1)/(Σ Tier2) ~1:2:2

Harvey B. Newman

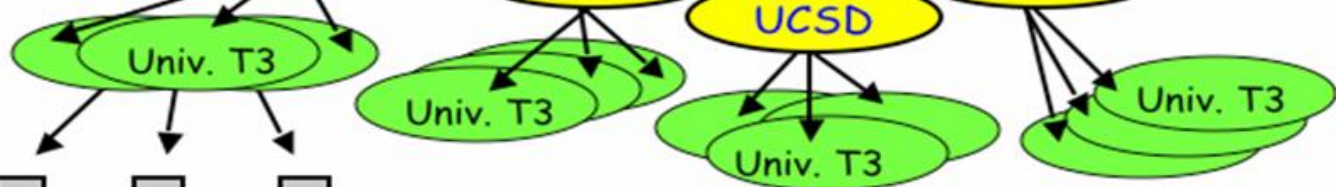
Tier 1



Tier 2



Tier 3



Tier 4



CERN/Outside Ratio Smaller; Expanded Role of Tier1s & Tier2s:
Greater Reliance on Networks

4 of 7 US CMS Tier2s Shown
With ~8 MSi2k; 1.5 PB Disk by 2007
>100 Tier2s at LHC

Grid and Clouds

Grid — to gather fraction of computing power from different organizations and different clusters in order to accumulate large computing resource.

Cloud — to share large computing resources between many users without system administrator intervention. From user point of view — to get required resources by clicking on web panel.

Conclusion

- Modern features of the computing systems
 - Heterogeneous computing clusters;
 - Free and Open Source Software as important factor;
 - Virtualization;
 - Grid and Cloud architectures.

End of Lecture

Is it possible to take participation in looking the features of the matter in LHC ?

- YES – pls see

<http://lhcatome.web.cern.ch/LHCatome/>