Role of Tier-3 level Azerbaijan National Grid Segment AZ-IFAN in the Worldwide LHC Computing Grid

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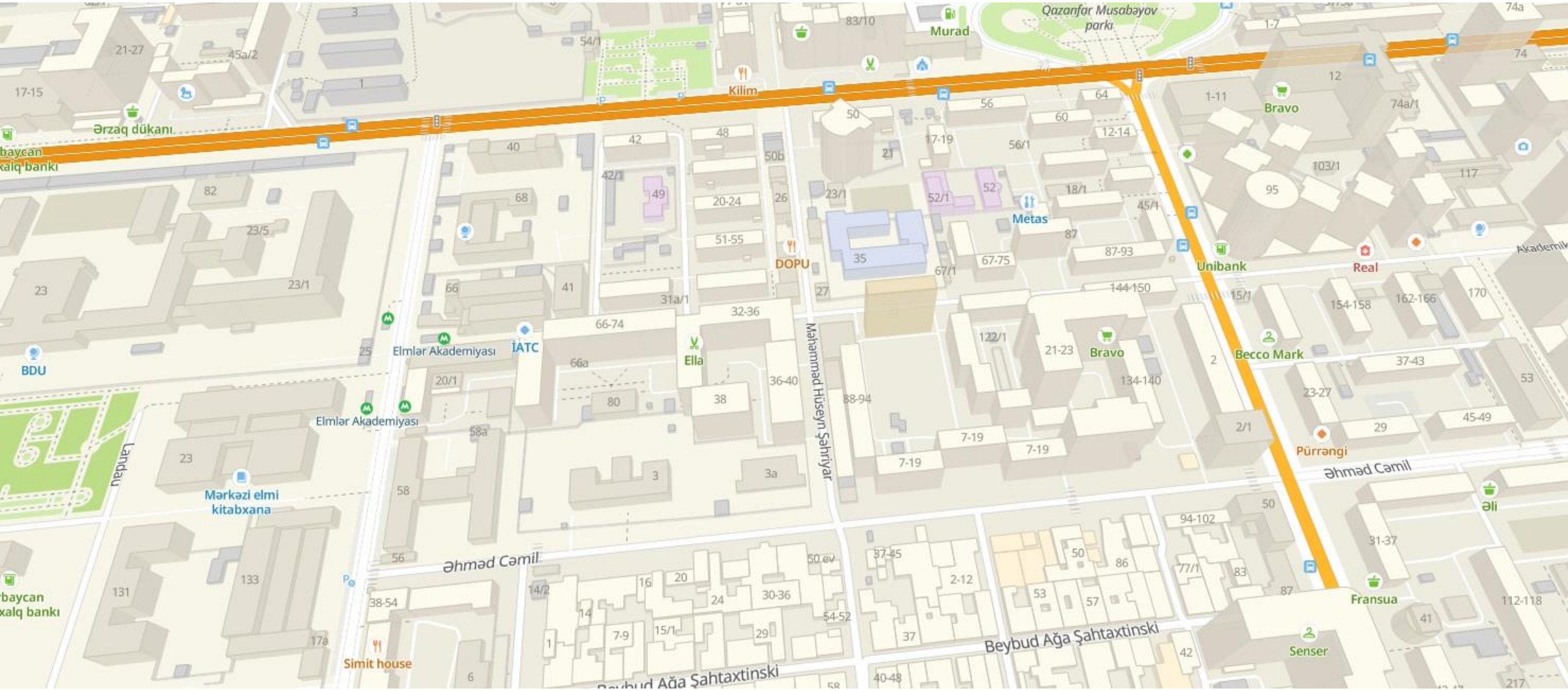
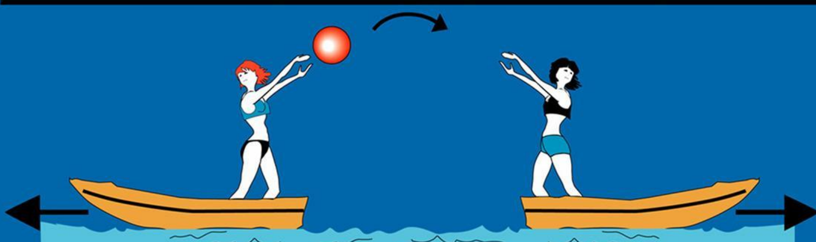
Baku Institute of Physics – Javid av. 131, AZ1143, Baku, Azerbaijan



Print Screen from www.2gis.az

The forces in Nature

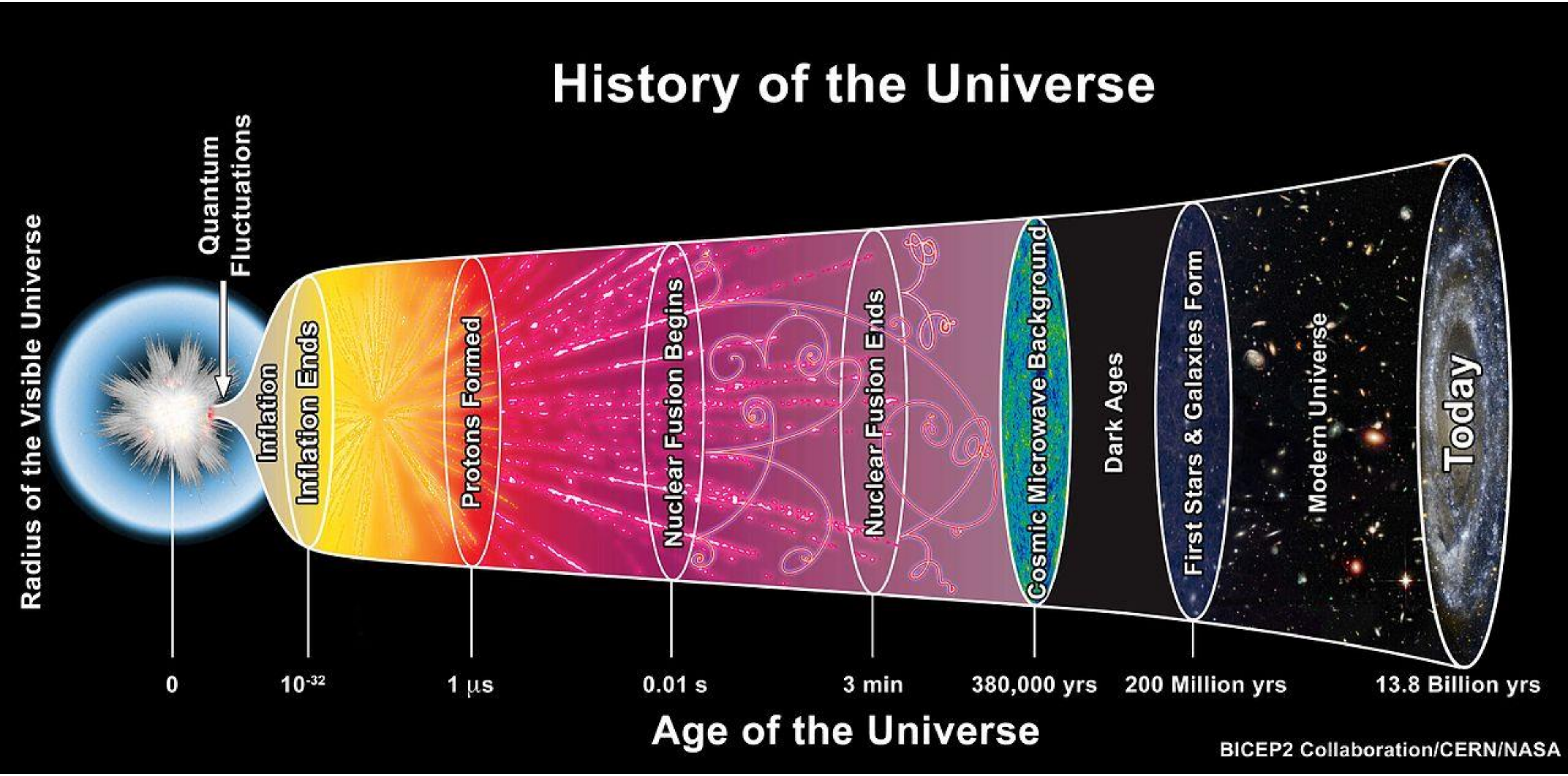
TYPE	INTENSITY OF FORCES (DECREASING ORDER)	BINDING PARTICLE (FIELD QUANTUM)	OCCURS IN :
STRONG NUCLEAR FORCE	~ 1	GLUONS (NO MASS)	ATOMIC NUCLEUS
ELECTRO -MAGNETIC FORCE	$\sim 10^{-3}$	PHOTONS (NO MASS)	ATOMIC SHELL ELECTROTECHNIQUE
WEAK NUCLEAR FORCE	$\sim 10^{-5}$	BOSONS Z^0 , W+ , W- (HEAVY)	RADIOACTIVE BETA DESINTEGRATION
GRAVITATION	$\sim 10^{-38}$	GRAVITONS (?)	HEAVENLY BODIES

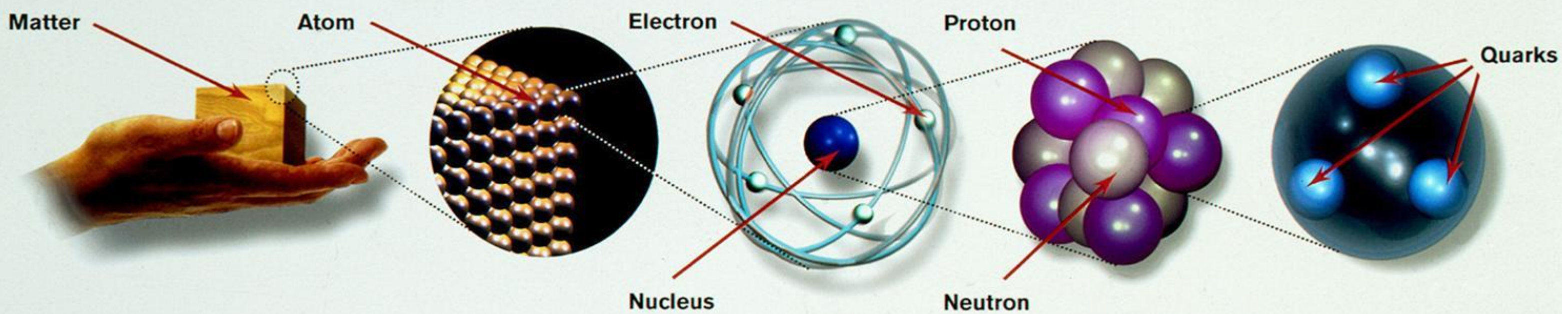


THE EXCHANGE OF PARTICLES IS RESPONSIBLE FOR THE FORCE

CERN AC _Z04_ V25/8/1992

Gravity	Weak (Electroweak)	Electromagnetic	Strong
Graviton (not yet observed)	W^+ W^- Z^0	Photon	Gluon
All	Quarks and Leptons	Quarks and Charged Leptons and W^+ W^-	Quarks and Gluons


History of the Universe
Radius of the Visible Universe
Quantum Fluctuations
Inflation
Inflation Ends
Protons Formed
Nuclear Fusion Begins
Nuclear Fusion Ends
Cosmic Microwave Background
Dark Ages
First Stars & Galaxies Form
Modern Universe
Today
0
10-32
1 μs
0.01 s
3 min
380,000 yrs
200 Million yrs
13.8 Billion yrs
Age of the Universe
BICEP2 Collaboration/CERN/NASA



Matter particles

All ordinary particles belong to this group

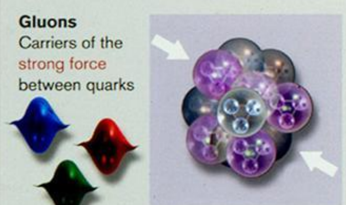
These particles existed just after the Big Bang. Now they are found only in cosmic rays and accelerators

	LEPTONS		QUARKS	
FIRST FAMILY	**Electron** Responsible for electricity and chemical reactions; it has a charge of -1	**Electron neutrino** Particle with no electric charge, and possibly no mass; billions fly through your body every second	**Up** Has an electric charge of plus two-thirds; protons contain two, neutrons contain one	**Down** Has an electric charge of minus one-third; protons contain one, neutrons contain two
SECOND FAMILY	**Muon** A heavier relative of the electron; it lives for two-millionths of a second	**Muon neutrino** Created along with muons when some particles decay	**Charm** A heavier relative of the up; found in 1974	**Strange** A heavier relative of the down; found in 1964
THIRD FAMILY	**Tau** Heavier still; it is extremely unstable. It was discovered in 1975	**Tau neutrino** not yet discovered but believed to exist	**Top** Heavier still	**Bottom** Heavier still; measuring bottom quarks is an important test of electroweak theory

Force particles

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

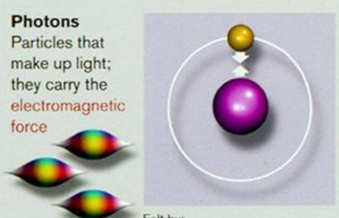
Gluons
Carriers of the strong force between quarks



Felt by: quarks

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

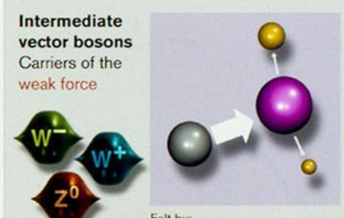
Photons
Particles that make up light; they carry the electromagnetic force



Felt by: quarks and charged leptons

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

Intermediate vector bosons
Carriers of the weak force



Felt by: quarks and leptons

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

Gravitons
Carriers of gravity

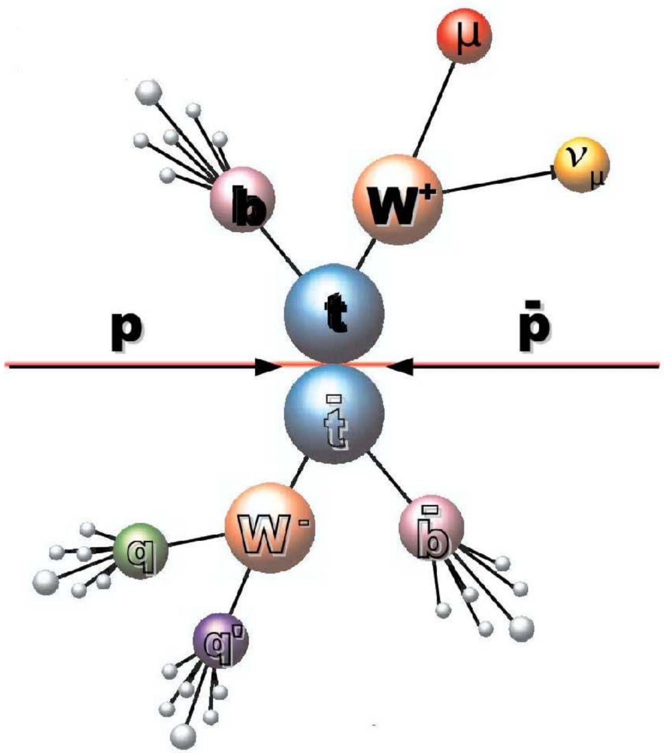
Felt by: all particles with mass

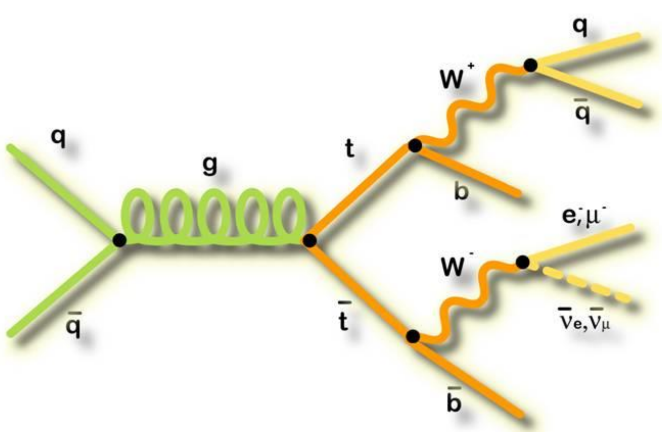
All the weight we experience is the result of the gravitational force

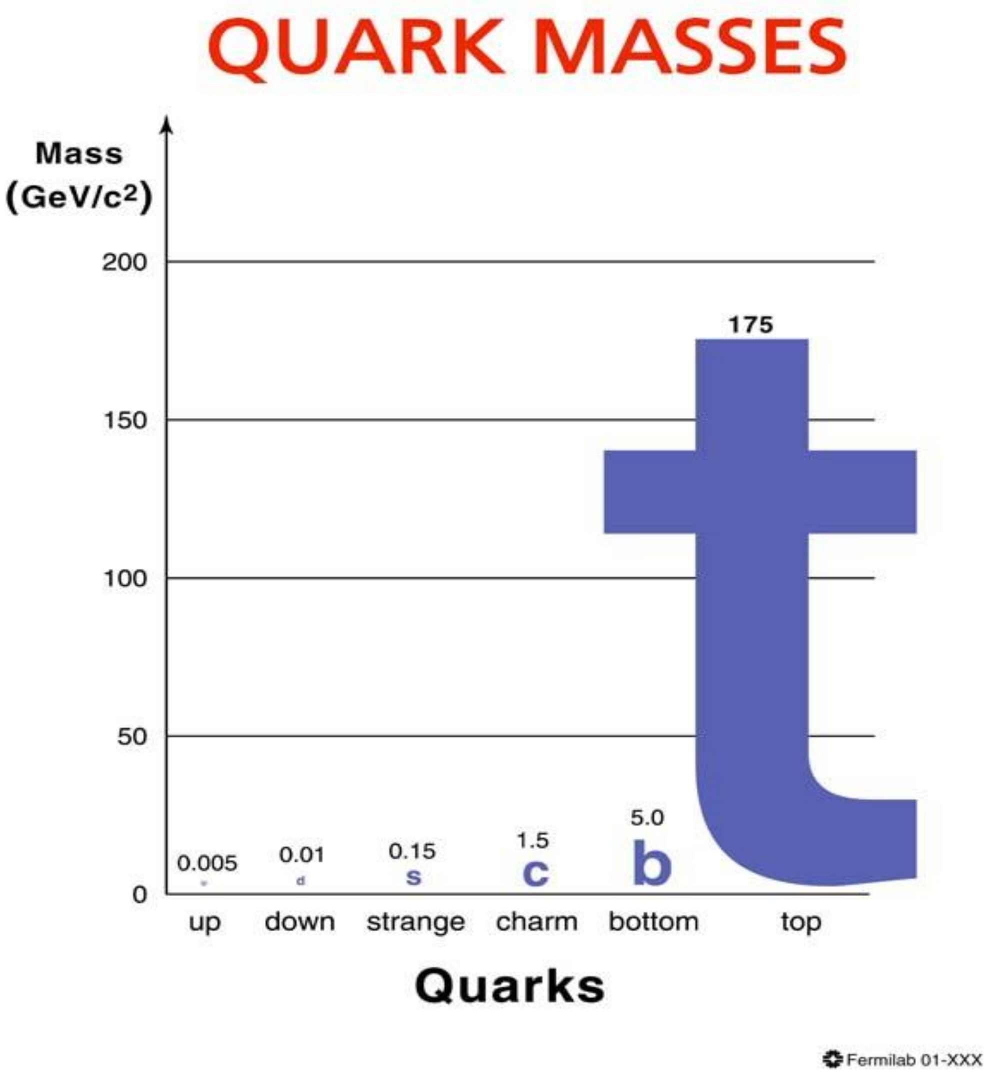
GRAPHICS: PETER CROWTHER

	HERA (DESY)	SPS (CERN)	Tevatron (Fermilab)	LHC (CERN)
Colliding particles	***ep***	***p-pbar***	***p-pbar***	***pp***
Max energy of beam, TeV	***e*: 0.030** ***p*: 0.920**	**0.315**	**1.0**	**7.0**
Luminosity ($10^{33}cm^{-2}c^{-1}$)	**14**	**6**	**210**	**10**
Length of the Ring, km	**6.336**	**6.911**	**6.28**	**26.659**

Tevatron Fermilab 1995

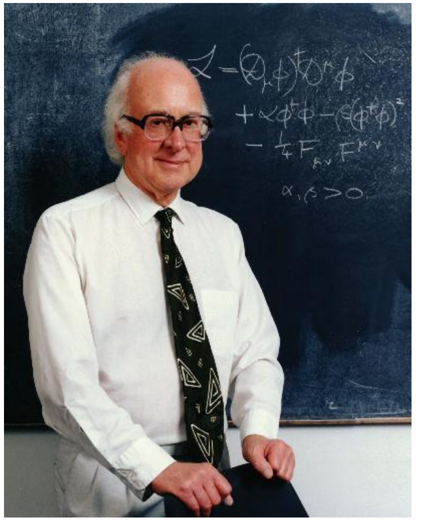






Higgs boson

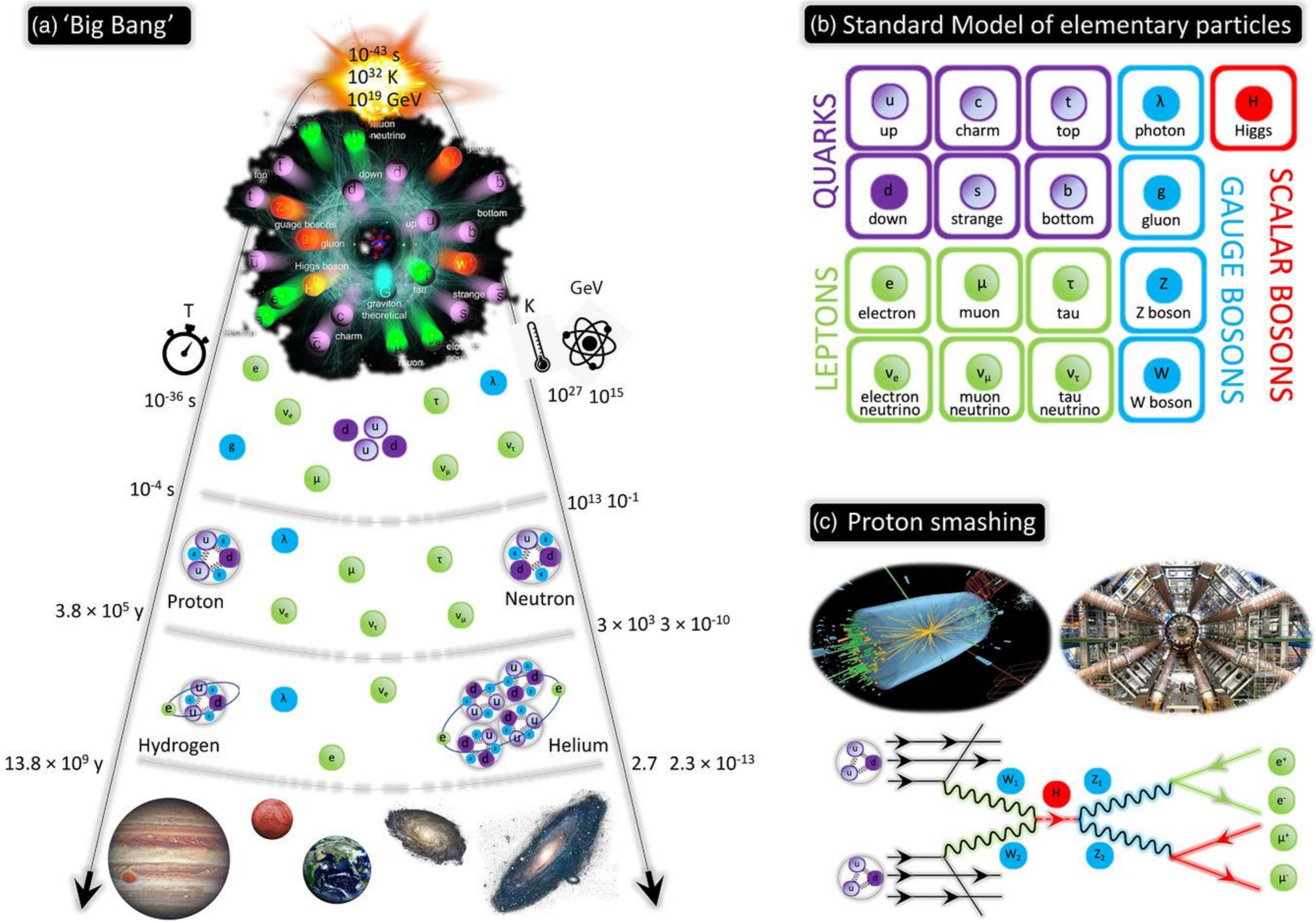
Main and last particle of the SM
(LHC – 2011-2013 ~ 125.25 GeV)



Nature of the spontaneous breakdown mechanism of the electroweak calibration invariance requires its existence as a scalar particles due to that it should give a mass to W and Z bosons.

M(H) > 114 GeV As a result of LEP II experimental run

M(H) < 160 GeV Higher threshold from LEP and Tevatron experimental data analysis



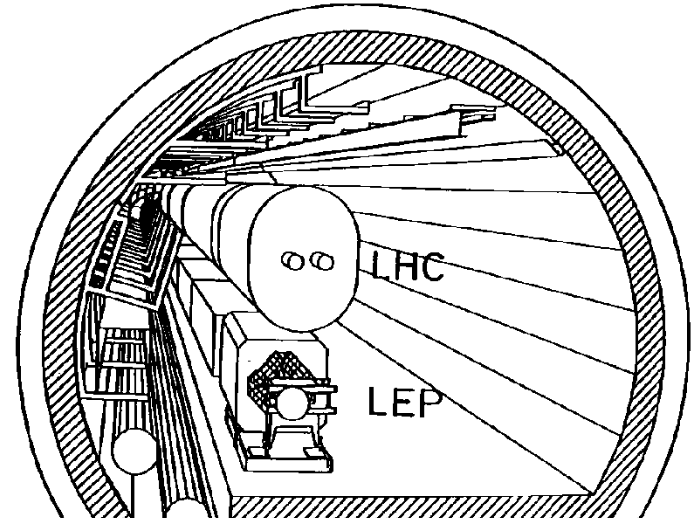
Experimental Physiology, Volume: 105, Issue: 3, Pages: 401-407, First published: 14 January 2020, DOI: (10.1113/EP088292)

The life of an experiment

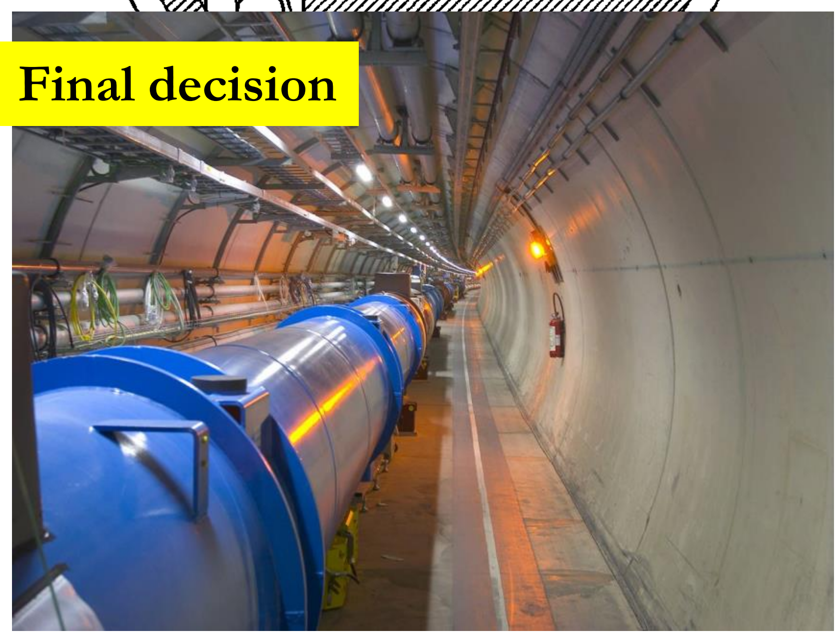
1984	Workshop in Lausanne on installing a Large Hadron Collider (LHC) in the LEP tunnel
1987	CERN's long-range planning committee chaired by Carlo Rubbia recommends LHC as the right choice for lab's future
1989	ECFA Study Week on instrumentation technology for a high-luminosity hadron collider; Barcelona; LEP collider starts operation
1990	ECFA LHC workshop, Aachen
1992	General meeting on LHC physics and detectors, Evian-les-Bains
1993	Letters of intent for LHC detectors submitted
1994	Technical proposals for ATLAS and CMS approved
1998	Construction begins
2000	CMS assembly begins above ground; LEP collider closes
2003	ATLAS underground cavern completed and assembly started
2004	CMS cavern completed
2007	Experiments ready for beam
2007	First proton–proton collisions
2008	First results
2010	Reach design luminosity
>2014	Upgrade LHC luminosity by factor of 10

Initial proposal

ECFA 84/85
CERN 84–10
5 September 1984



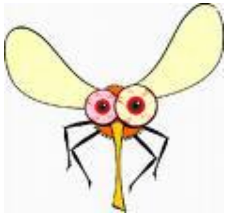
Final decision



Parameters of the proton beam

Speed of proton in the ring: v = **0,99999998 c;**

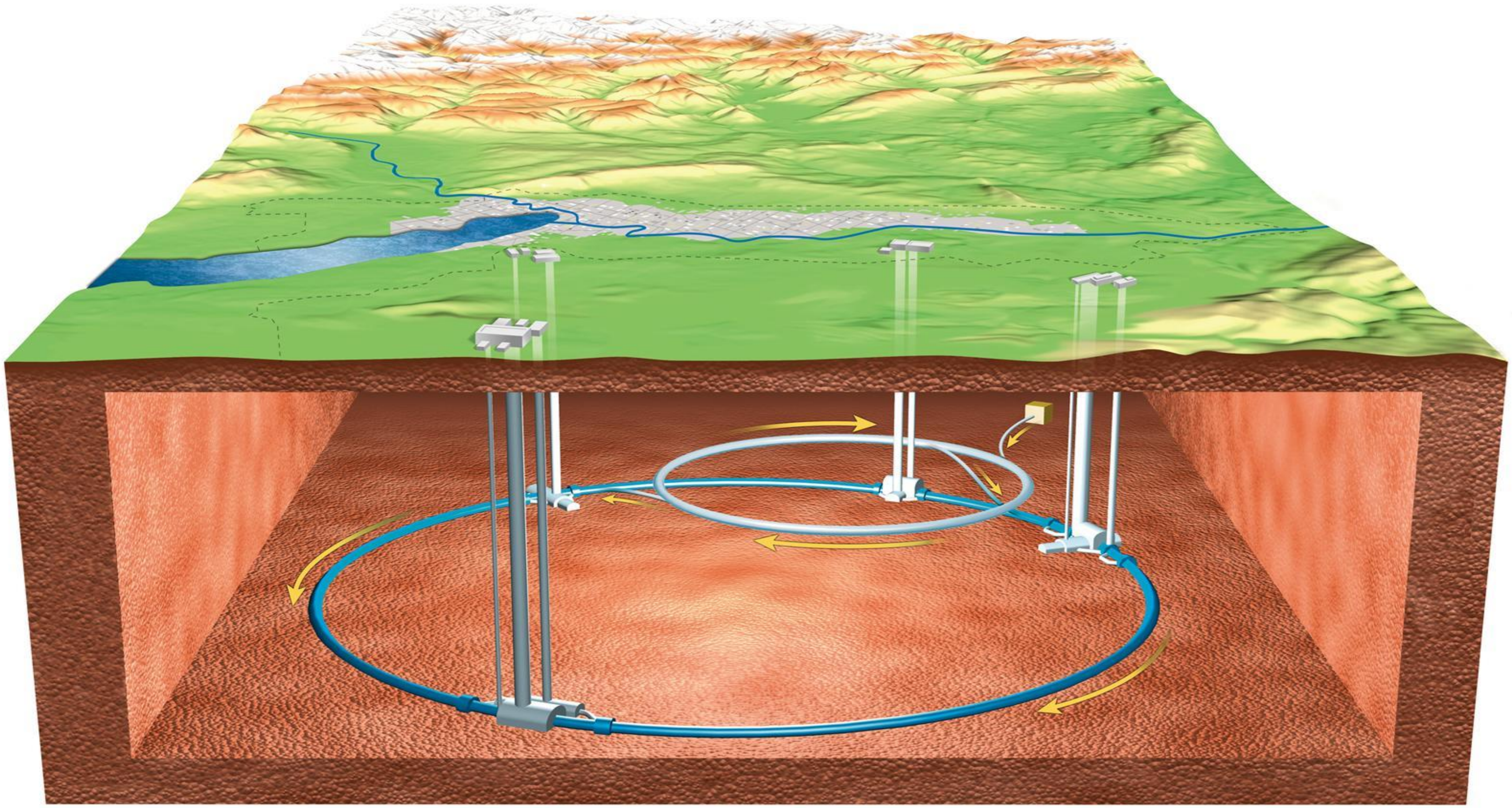
Energy of proton beam**=** **7 TeV ≈10^{-6} J**, it is close to the kinetic energy of the single flying mosquito



Full energy in the LHC ring:

2808 bunches × 10^{11} proton/bunch × 7 TeV/proton = 360 MJ

Kinetic energy of the big aircraft carrier moving with speed 8 knot!



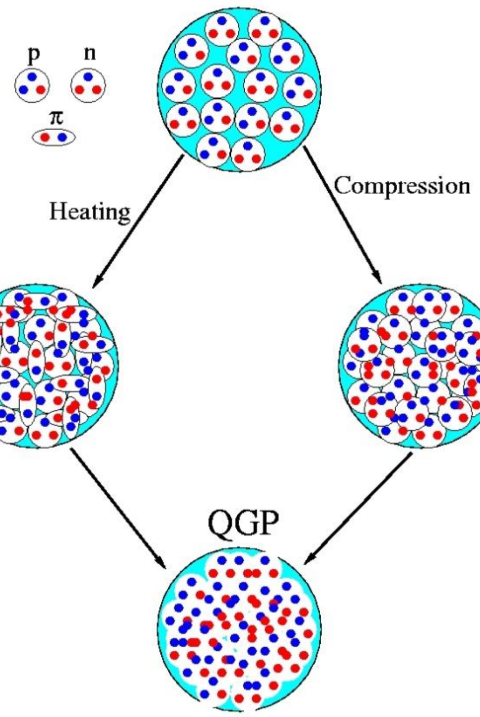
50-175 meters depth

Energy and luminosity of LHC:

10-14 Tev pp collision (maximum luminosity $L=10^{34} cm^{-2} sec^{-1}$)

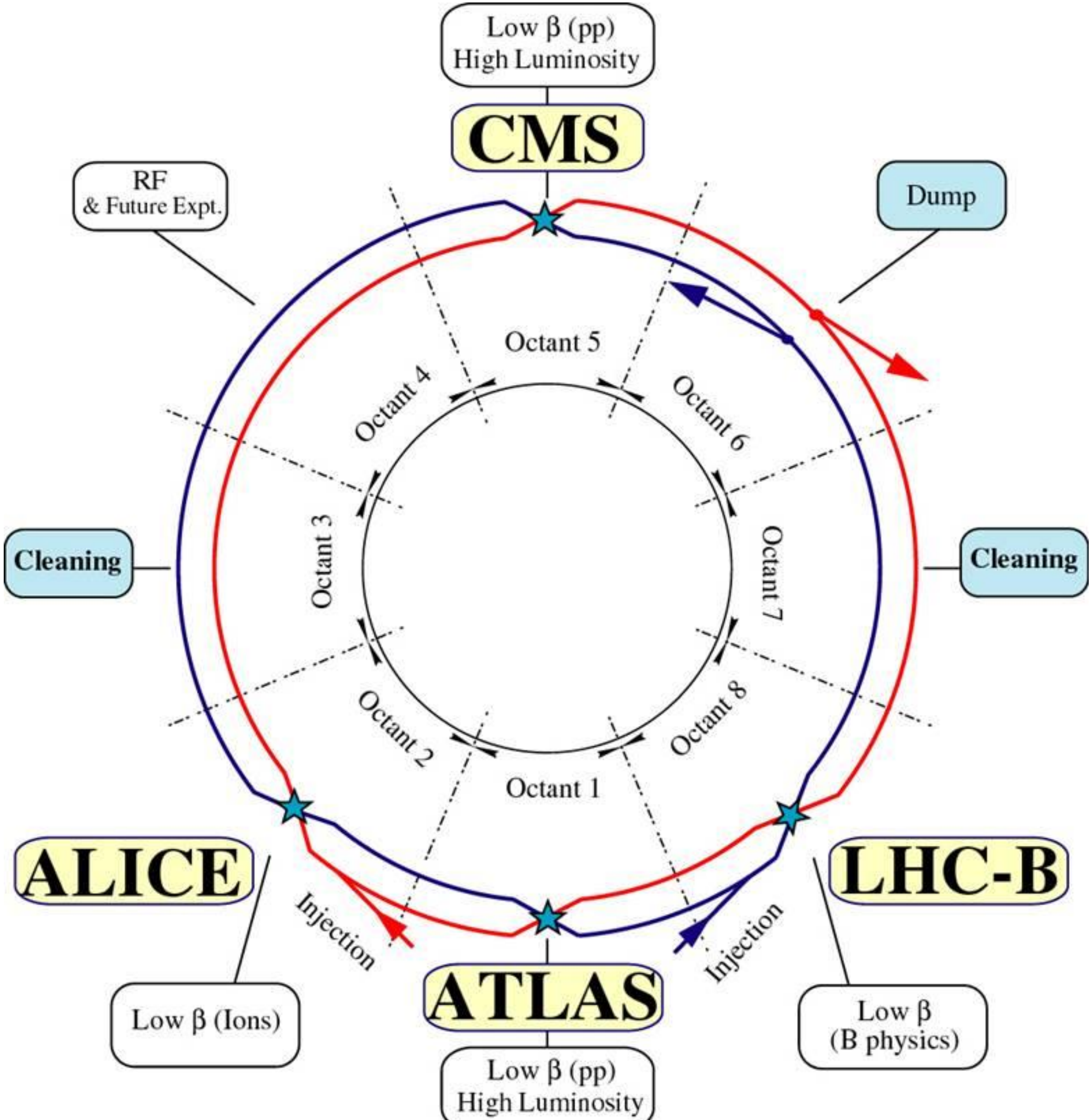
4-5.5 TeV PbPb collision (maximum luminosity $L=10^{27} cm^{-2} sec^{-1}$)

Quark-Gluon Plasma



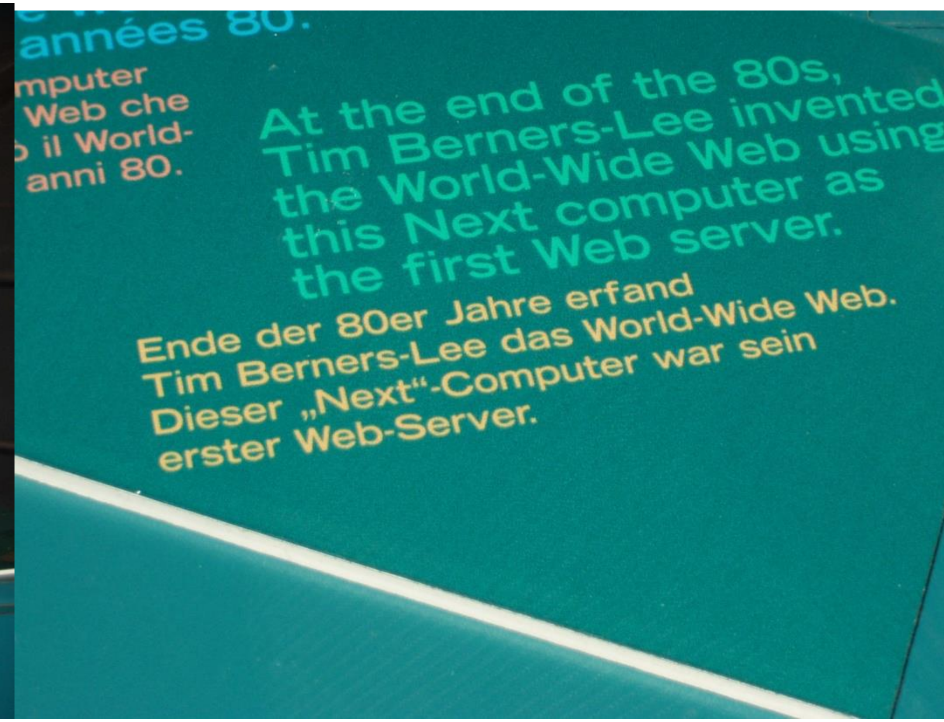
http://lhc-first-beam.web.cern.ch/lhc-first-beam/Welcome.html

“A historic moment in the CERN Control Centre: the beam was successfully steered around the accelerator.”



Low β (pp)
High Luminosity
CMS
RF
& Future Expt.
Dump
Octant 5
Octant 4
Octant 6
Octant 3
Octant 7
Cleaning
Cleaning
Octant 2
Octant 8
Octant 1
ALICE
LHC-B
Injection
Injection
ATLAS
Low β (Ions)
Low β
(B physics)
Low β (pp)
High Luminosity

(WWW) – First PC – CERN Microcosm Museum



First reaction from CERN Administration was: “Looks vague, but exciting”

Control room

DOWN THE PETABYTE HIGHWAY

For scientists, collisions at the world's most powerful particle collider are just the start. Nature *follows the torrent of data on its circuitous journey around the world.*

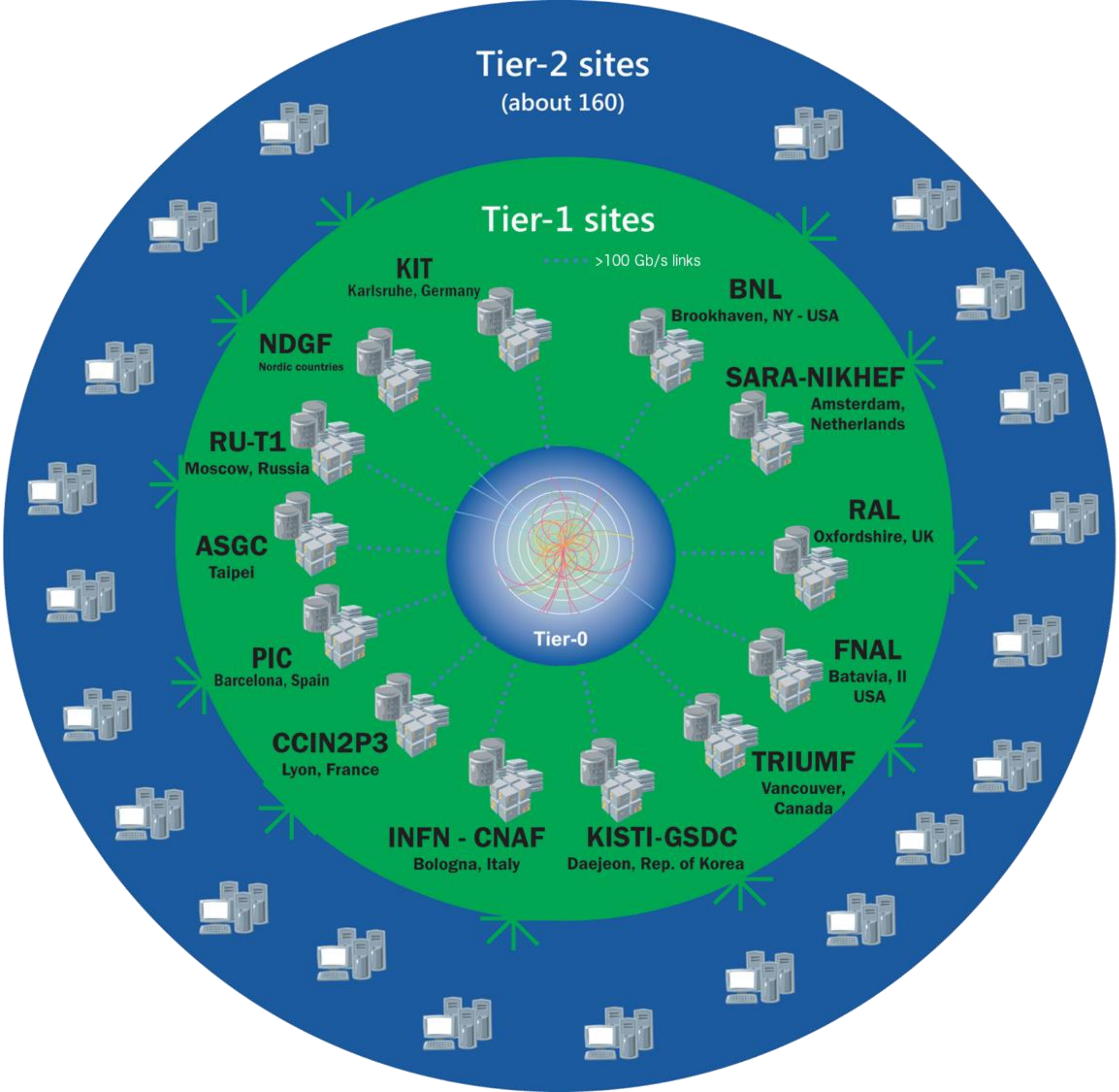
BY GEOFF BRUMFIEL

ATLAS PARTICLE DETECTOR, SWITZERLAND, 30 MARCH 2010, *13:06* LOCAL TIME

Beneath gently rolling hills between the mountains of Switzerland and France, the fields such as genomics and climate science (see *Nature* **455**, 16–21; 2008). And the analyses are more complex too. Particle physicists must study millions of collisions at once to find the signals buried in them — information on dark calibration, along with temperature readings and other environmental data from the cavern where ATLAS is housed, are used to piece each event back together. ATLAS scientists at CERN pull up reconstructions

CERN

Nature **volume 469**, pages 282–283 (2011)
https://doi.org/10.1038/469282a


Tier-2 sites
(about 160)
Tier-1 sites
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KIT
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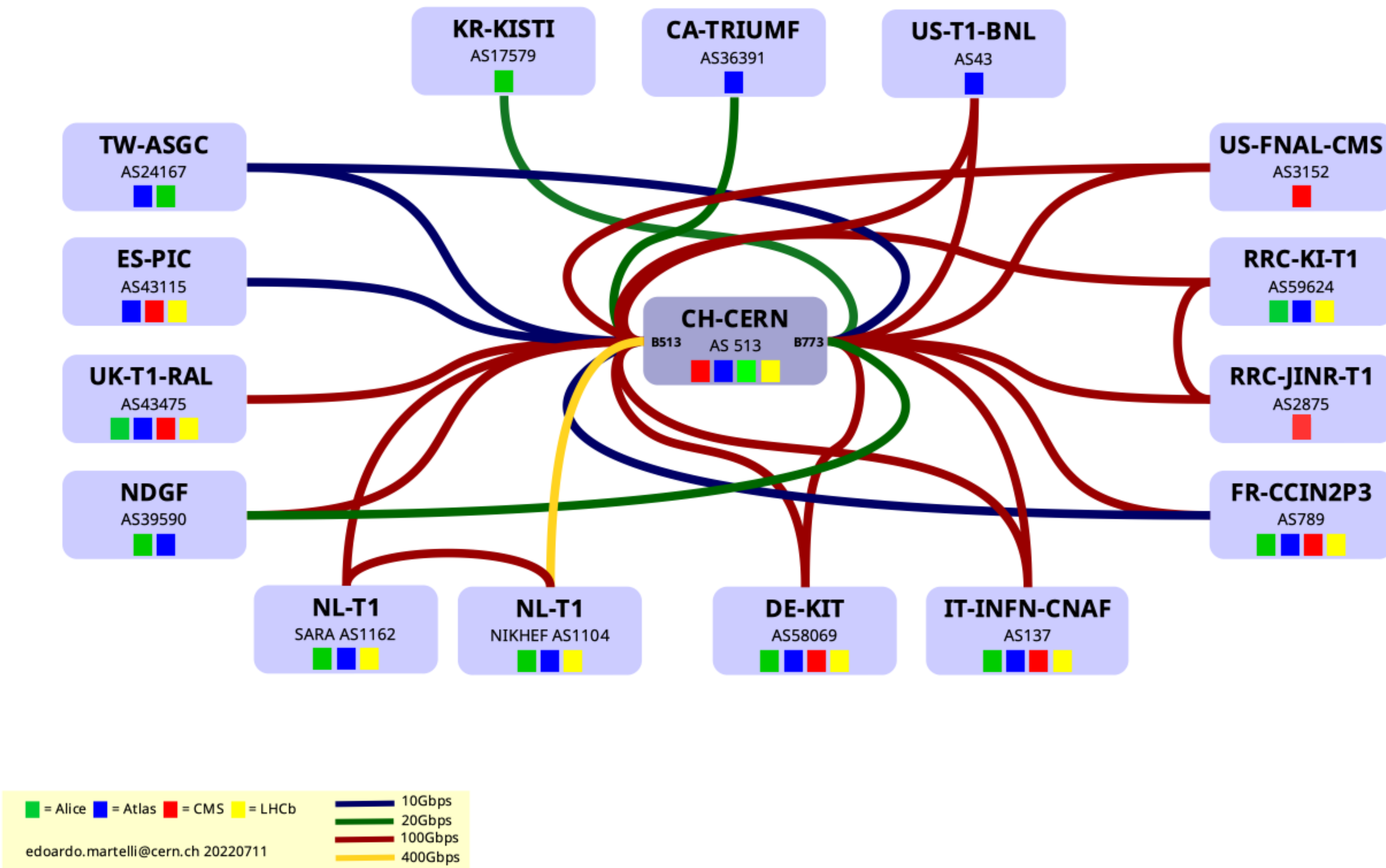
BNL
Brookhaven, NY - USA
NDGF
Nordic countries
SARA-NIKHEF
Amsterdam, Netherlands
RU-T1
Moscow, Russia
RAL
Oxfordshire, UK
ASGC
Taipei
Tier-0
PIC
Barcelona, Spain
FNAL
Batavia, Il USA
CCIN2P3
Lyon, France
TRIUMF
Vancouver, Canada
INFN - CNAF
Bologna, Italy
KISTI-GSDC
Daejeon, Rep. of Korea

LHCOPN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TW-ASGC
AS24167
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AS43115
RRC-KI-T1
AS59624
CH-CERN
B513
AS 513
B773
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AS43475
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SARA AS1162
NL-T1
NIKHEF AS1104
DE-KIT
AS58069
IT-INFN-CNAF
AS137
= Alice = Atlas = CMS = LHCb
edoardo.martelli@cern.ch 20220711
10Gbps
20Gbps
100Gbps
400Gbps

Site Name	Country	Federations	Tier	Status	State	ALICE	ATLAS	CMS
AGLT2	United States	US-AGLT2	2	production	ACTIVE		AGLT2	
AM-04-YERPHI	Armenia	NON-MOU-Federation	3	production	ACTIVE	Yerevan	AM-04-YERPHI	
ANLASC	United States	NON-MOU-Federation	3	production	ACTIVE		ANLASC, ARGO	
Arizona	United States	NON-MOU-Federation	3		ACTIVE		Arizona	
ARNES	Slovenia	NON-MOU-Federation	3	production	ACTIVE		ARNES	
Australia-ATLAS	Australia	AU-ATLAS	2	production	ACTIVE		Australia-ATLAS, Australia-NECTAR	
AUVERGRID	France	NULL		production	ACTIVE		AUVERGRID	
AYDIN	Turkey	NON-MOU-Federation	3		ACTIVE		AYDIN	
AZ-IFAN	Azerbaijan	NON-MOU-Federation	3	production	ACTIVE		AZ-IFAN	
Azure	Switzerland	NON-MOU-Federation	3		ACTIVE			
Baylor-Kodiak	United States	NON-MOU-Federation	3	production	ACTIVE			T3_US_Baylor


AZ-IFAN (Azerbaijan National Grid Segment)
Data center of Institute of Physics of ANAS
View site
Карта
Спутник
Исландия
Канада
Соединенные Штаты Америки
Северная часть Атлантического океана
Казахстан
Монголия
Китай
Ирак
Иран
Алжир
Ливия
Египет
Саудовская Аравия
Индия
Мали
Нигер
Судан
Чад
Нигерия
Венесуэла
Колумбия
ДР Конго
Танзания
Индонезия
Перу
Бразилия
Боливия
Ангола
Намибия
Мадагаскар
Индийский океан
Южная часть Атлантического океана
Австралия
Google
Картографические данные © 2018
Условия использования

AZ-IFAN

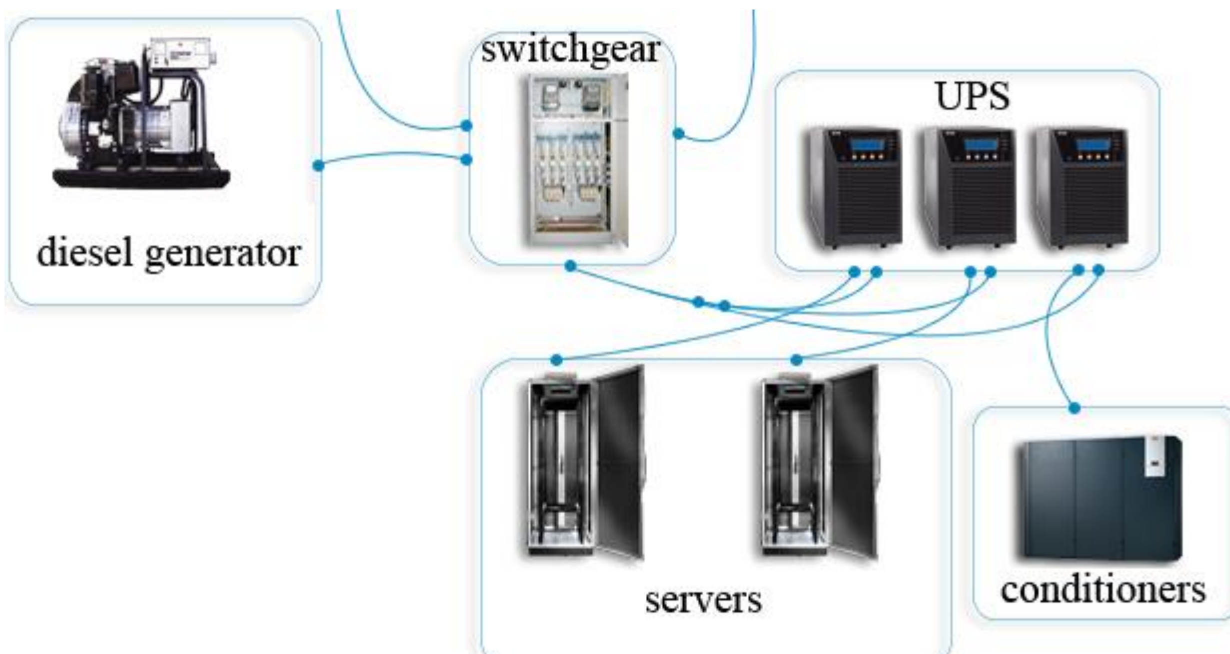
- Data-center AZ-IFAN was established in 2008 within the active support of CERN, Azerbaijan National Academy of Sciences and its main institute providing IT technologies – Institute of Information Technologies.
- GRID, cluster and cloud technologies are main directions of the development of our data center.
- AZ-IFAN users are able to solve their problems in the field of high energy physics, nanotechnologies and etc. thanks to established opportunities for them by the data center.
- The center is developing mainly thanks to efficient collaboration with CERN and local governmental and research units.

Infrastructure of AZ-IFAN consists of high-productive blade servers Supermicro, as well as blade server IBM, supplied by Baku Institute of Information Technologies.

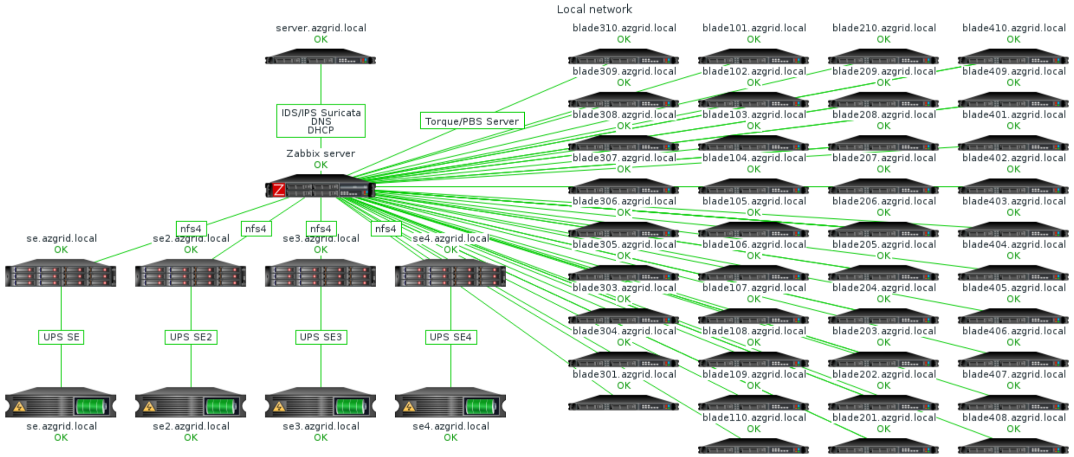
Storage ~300 TB.
Number of kernels 700.
Internet speed 1 gb/ps
Local network 1 gb/ps

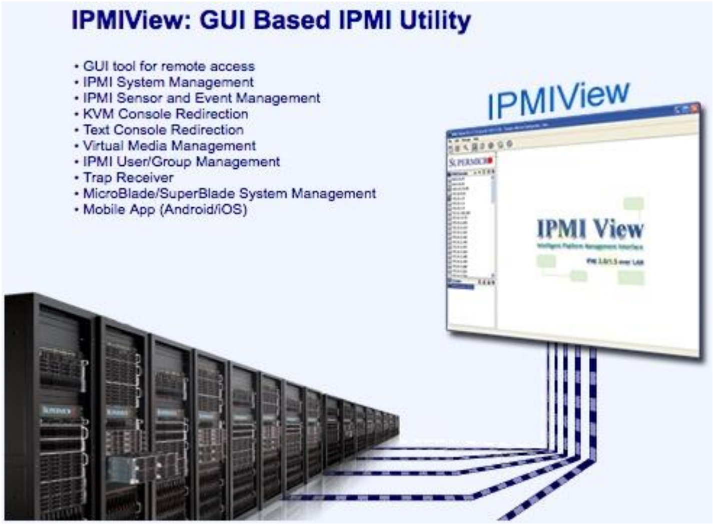
AZ-IFAN operates in regime 24/7.
Equipment protection is achieved thanks to sufficient number of UPSs and other protecting installations.

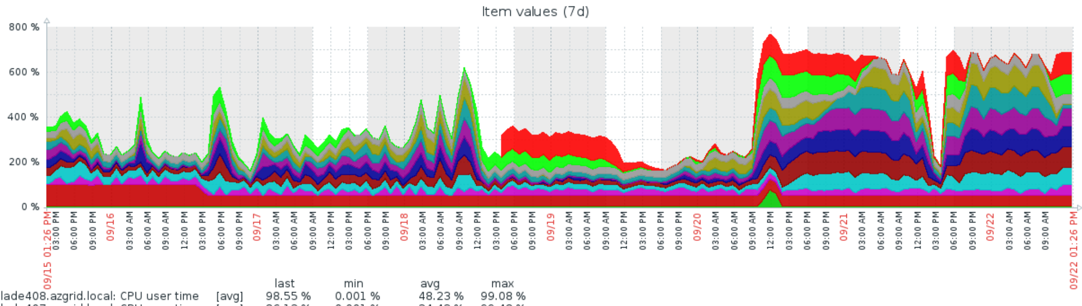
Climate control system preserves the temperature on the level: 18 °C.



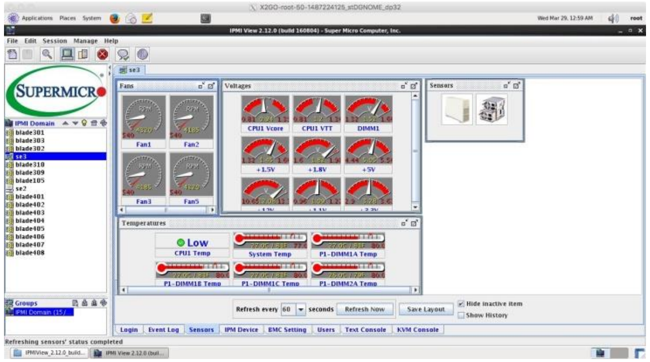
Necessary monitoring and administration of the data center resources are implemented thanks to local system ZABBIX and special software package from Supermicro server





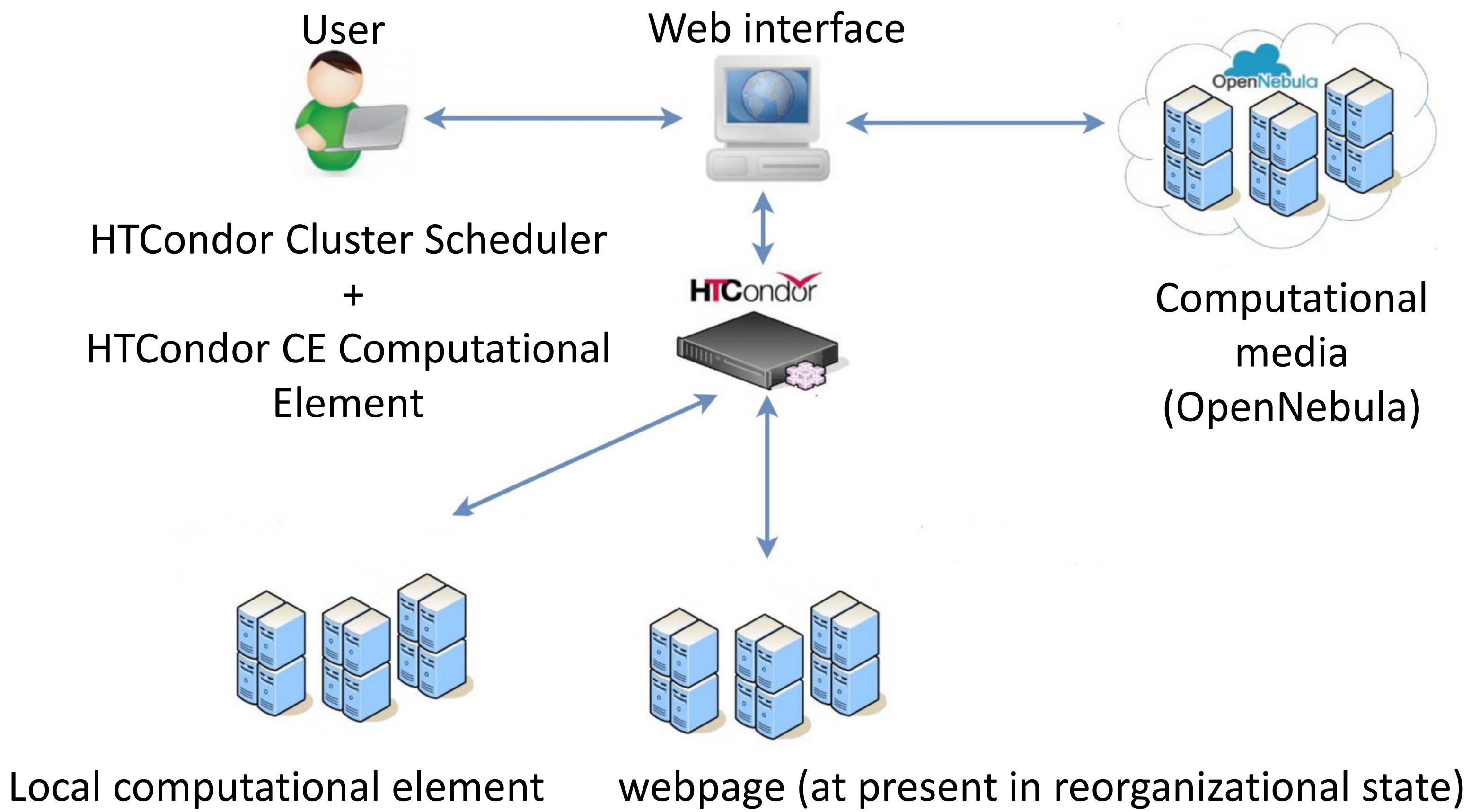


		last	min	avg	max
blade408.azgrid.local: CPU user time	[avg]	98.55 %	0.001 %	48.23 %	99.08 %
blade407.azgrid.local: CPU user time	[avg]	86.12 %	0.001 %	24.43 %	99.48 %
blade406.azgrid.local: CPU user time	[avg]	45.39 %	0.0021 %	35.98 %	74.18 %
blade405.azgrid.local: CPU user time	[avg]	2.97 %	0.001 %	33.01 %	99.33 %
blade404.azgrid.local: CPU user time	[avg]	14.88 %	1.39 %	37.87 %	98.95 %
blade403.azgrid.local: CPU user time	[avg]	81.31 %	0.001 %	40.34 %	99.28 %
blade402.azgrid.local: CPU user time	[avg]	92.55 %	0.001 %	38.17 %	99.39 %
blade401.azgrid.local: CPU user time	[avg]	91 %	0.0021 %	42.3 %	99.37 %
blade210.azgrid.local: CPU user time	[avg]	0.0099 %	0.001 %	0.01 %	0.45 %
blade209.azgrid.local: CPU user time	[avg]	0.0084 %	0 %	0.008655 %	0.46 %
blade208.azgrid.local: CPU user time	[avg]	0.0098 %	0.001 %	0.01 %	0.45 %
blade203.azgrid.local: CPU user time	[avg]	75.33 %	1.78 %	39.49 %	93.27 %
blade108.azgrid.local: CPU user time	[avg]	49.96 %	0.0032 %	24.3 %	75.31 %
blade105.azgrid.local: CPU user time	[avg]	0.0094 %	0.001 %	0.01 %	0.42 %
blade103.azgrid.local: CPU user time	[avg]	48.61 %	41.11 %	56.62 %	99.44 %
blade102.azgrid.local: CPU user time	[avg]	0.0087 %	0.001 %	1.01 %	75.51 %



Infrastructure of the data center can be formally divided to the following segments:

- Computational cluster
- GRID infrastructure
- Cloud infrastructure



Applied software support from the computational cluster of the Institute of Physics:

The package Abinit — freeware software that is used widely for computation of the full energy, electron density etc.
It is installed with support of Open MPI.

The package Wien2k— it is a computer program written in Fortran which performs quantum mechanical calculations on periodic solids.
It is installed with support of FFTW.

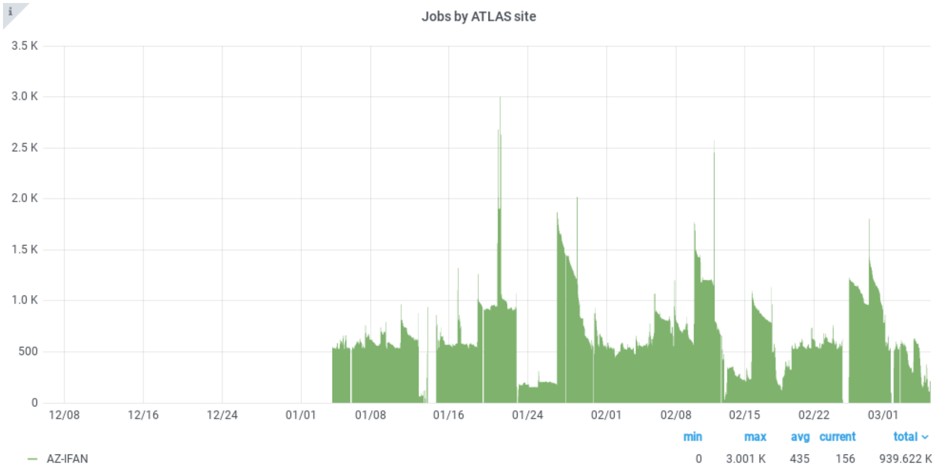
The package Quantum Espresso - it is a freeware package being used for first-principles electronic-structure calculations and materials modeling.
It is also installed with support of Open MPI.

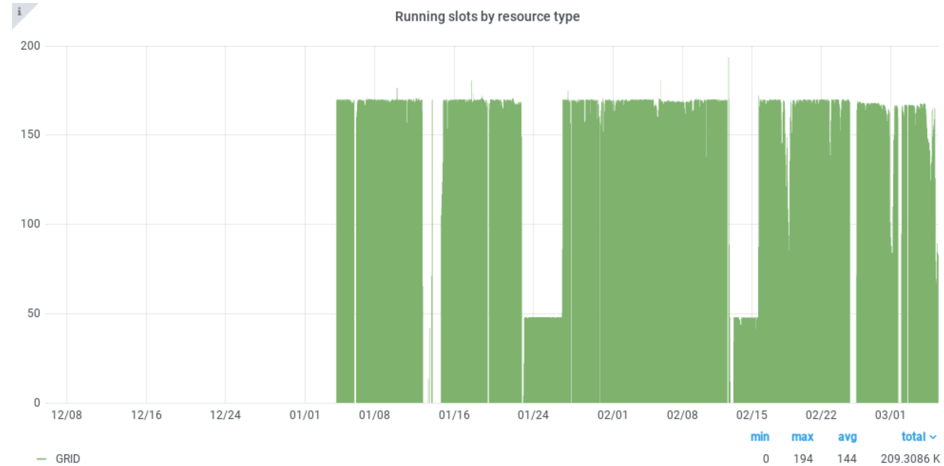
Kohn-Sham equation

$$\left(-\frac{\hbar^2}{2m}\nabla^2 + v_{\text{eff}}(\mathbf{r})\right)\varphi_i(\mathbf{r}) = \varepsilon_i\varphi_i(\mathbf{r})$$

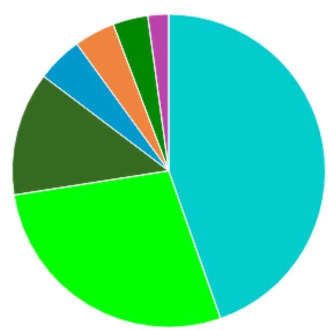
This equation being main equation of the quantum chemistry
looks like Schrödinger equation, but it is only Schrödinger-like.
Walter Kohn having bachelor and MSC background in applied mathematics
and PhD title in theoretical physics received a 1998 year Nobel prize in chemistry
exactly for this equation that allows to perform solid state software computations
for the many-body quantum systems, which are sufficiently complex and for today
their exact solutions are impossible.

Monitoring data of AZ-IFAN GRID site
By using ATLAS web-portal





Completed jobs



	total	percentage
MC Simulation Full	27.2 K	45%
Testing	17.0 K	28%
MC Event Generation	7.80 K	13%
MC Simulation Fast	2.884 K	5%
MC Merge	2.577 K	4%
Group Production	2.208 K	4%
Event Index	1.309 K	2%

Thank You!