CERN Day
UPB, Oct 2022

Costin.Grigoras@cern.ch

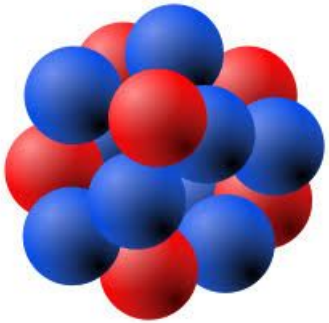
Welcome to CERN

Science and innovation accelerator

CERN seeks answers…

… to fundamental questions

- What can we learn about the birth of the universe?



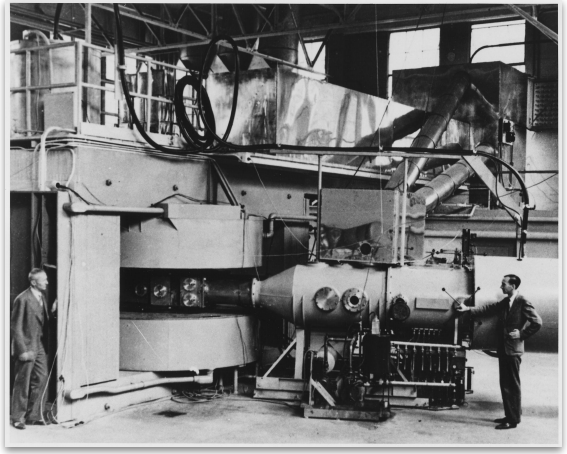
- What is the matter around us made of?

- What forces are at the origin of the phenomenon we observe?

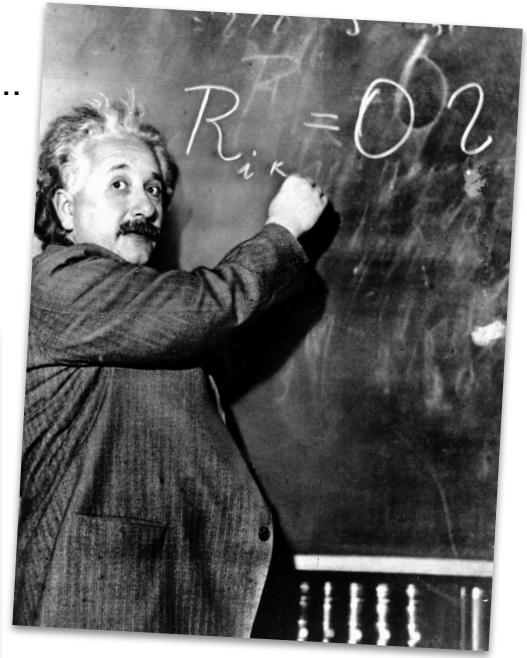
CERN is founded after the WWII

Europe is devastated, so are its research resources

The US and Russia take the lead in fundamental research



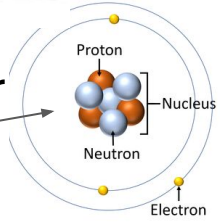
Brain drain to USA...



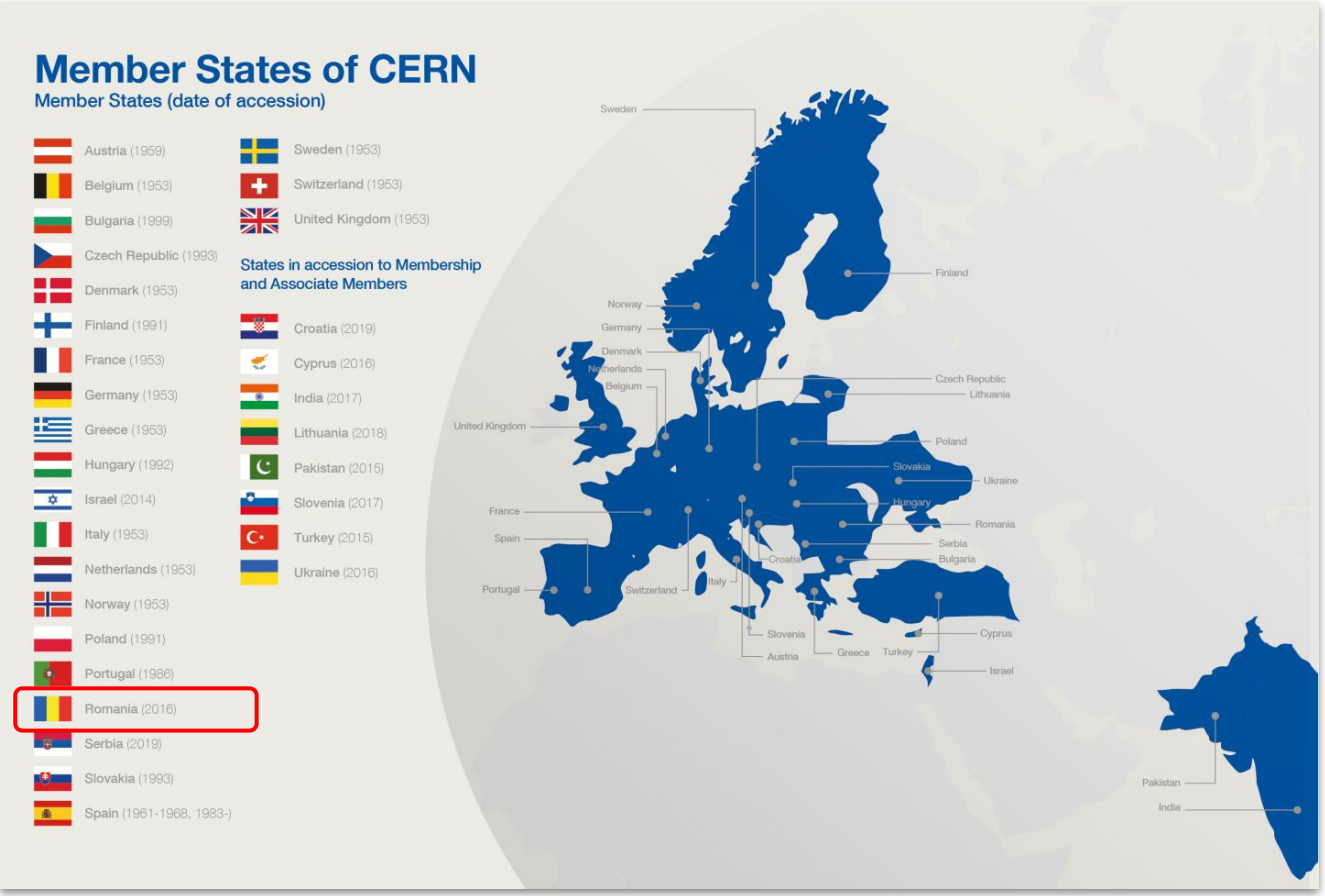
CERN is founded after the WWII

CERN is founded by 12 European States on September 29, 1954 - almost 70 years ago

CERN = Conseil Européen pour la Recherche Nucléaire



Today - the world largest laboratory for particle physics



Yearly budget:

~ 1000 MCHF

Personnel:

~2660 Staff members

~840 Fellows

~350 Students

~12000 Users

Observers:

EU, USA, Russian Federation, Japan, UNESCO

Distribution of All CERN Users by Nationality on 27 January 2020

MEMBER STATES **7 149**

Austria	95
Belgium	113
Bulgaria	71
Czech Republic	216
Denmark	52
Finland	72
France	778
Germany	1 177
Greece	216
Hungary	77
Israel	59
Italy	1 856
Netherlands	170
Norway	59
Poland	311
Portugal	94
Romania	144
Serbia	49
Slovakia	128
Spain	405
Sweden	74
Switzerland	204
United Kingdom	729

OBSERVERS **2 506**

Japan	274
Russia	1 126
USA	1 106

ASSOCIATE MEMBERS IN THE PRE-STAGE TO MEMBERSHIP **54**

Cyprus	21
Slovenia	33

ASSOCIATE MEMBERS **770**

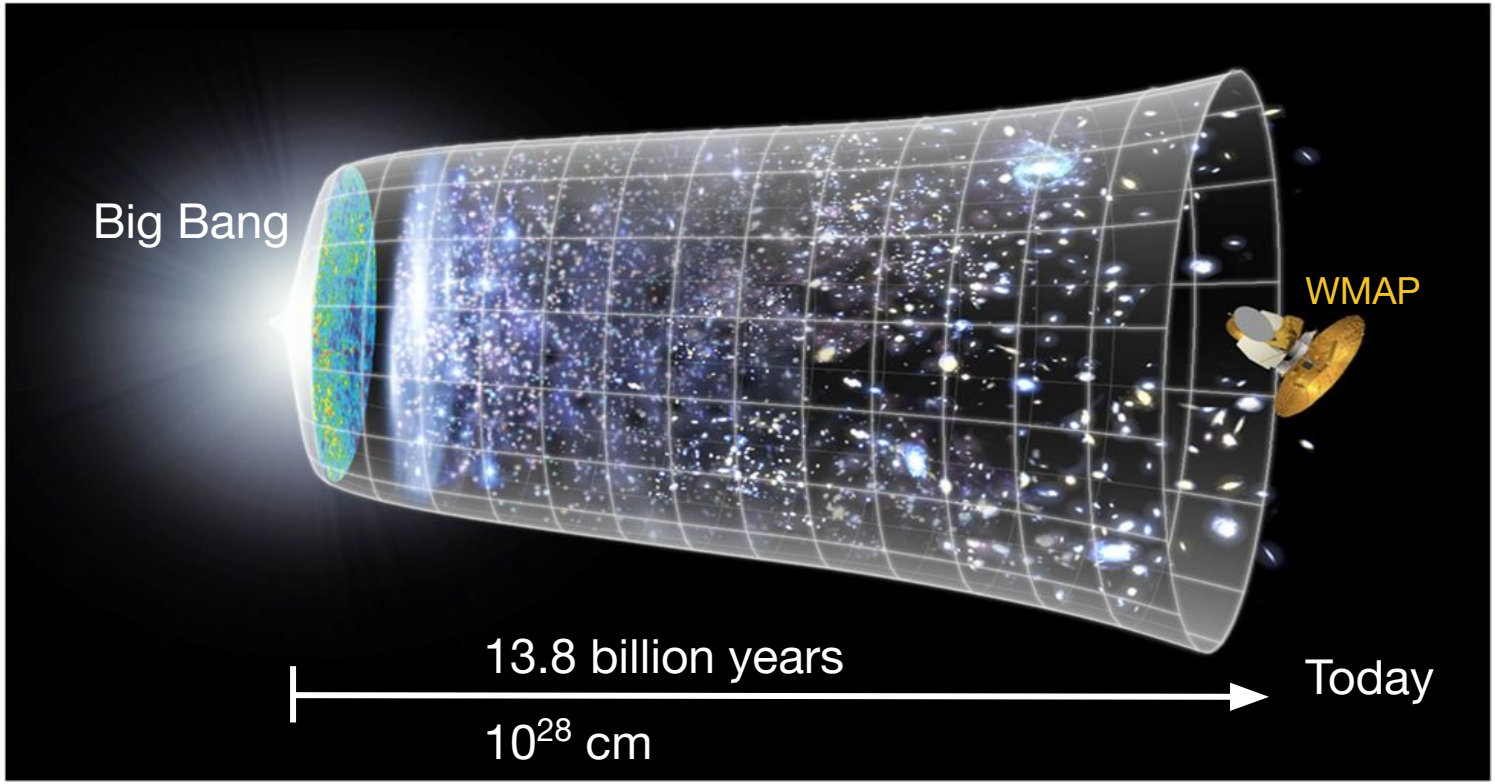
Croatia	47
India	367
Lithuania	31
Pakistan	63
Turkey	162
Ukraine	100

OTHERS **1 822**

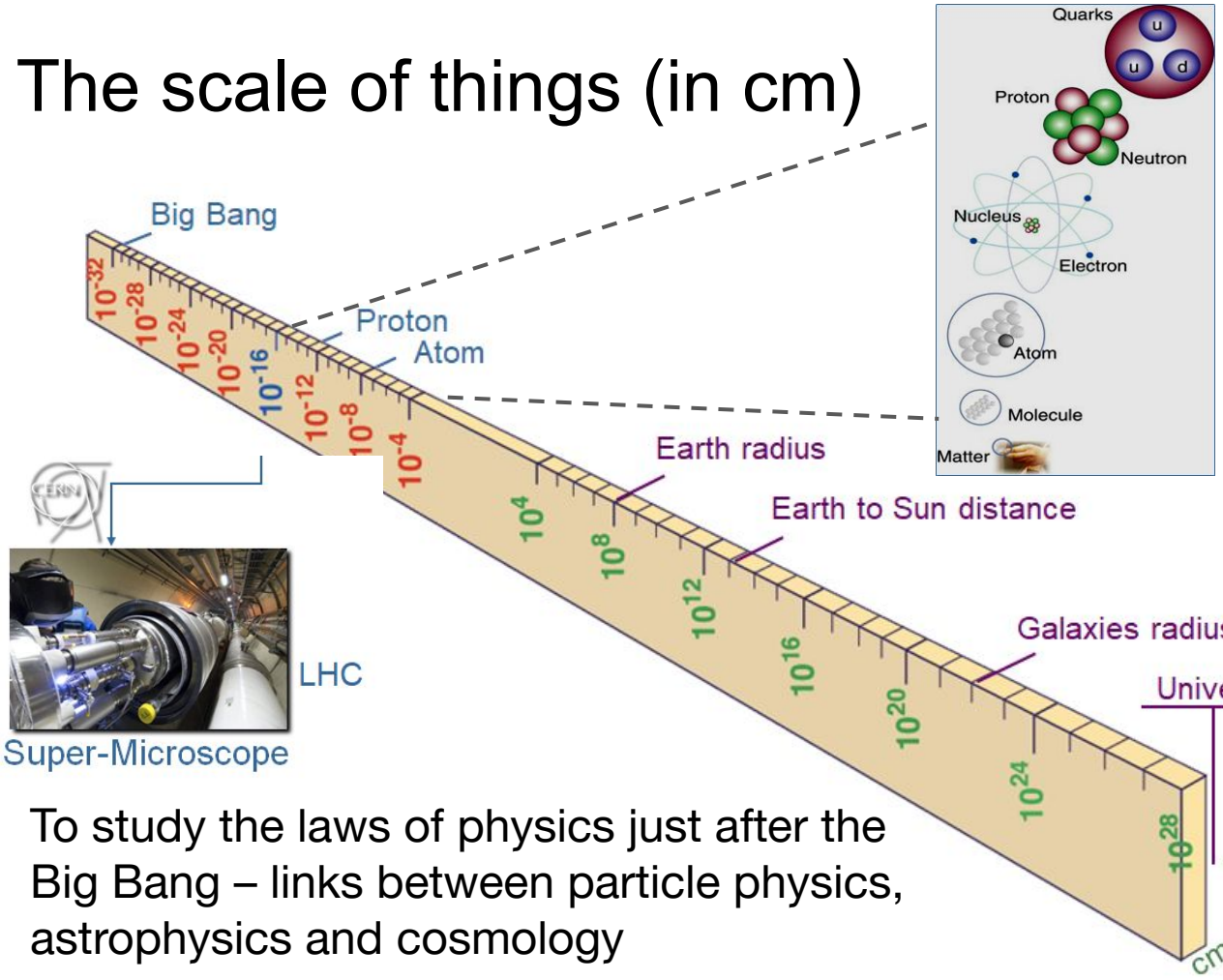
Albania	4	Bolivia	2	Egypt	26	Ireland	14	Montenegro	8	Saint Kitts		Uzbekistan	3
Algeria	8	Bosnia & Herzegovina	2	El Salvador	1	Jamaica	1	Morocco	26	and Nevis	1	Venezuela	10
Argentina	22	Bostwana	1	Estonia	16	Jordan	2	Myanmar	1	Saudi Arabia	2	Viet Nam	10
Armenia	18	Brazil	121	Georgia	54	Kazakhstan	12	Nepal	8	Senegal	1	Yemen	1
Australia	28	Burundi	1	Ghana	1	Kenya	1	New Zealand	6	Singapore	4	Zambia	1
Azerbaijan	7	Canada	155	Gibraltar	1	Korea	161	Nigeria	2	South Africa	54	Zimbabwe	1
Bahrain	3	Chile	21	Guatemala	1	Kyrgyzstan	1	North Korea	3	Sri Lanka	6		
Bangladesh	5	China	569	Hong Kong	1	Latvia	4	North Macedonia	2	Sudan	2		
Belarus	49	Colombia	35	Honduras	1	Lebanon	23	Oman	1	Syria	2		
Benin	1	Congo	1	Iceland	5	Luxembourg	3	Palestine	7	Taiwan	47		
		Costa Rica	1	Indonesia	11	Malaysia	19	Paraguay	1	Thailand	24		
		Cuba	16	Iran	46	Malta	5	Peru	6	Tunisia	5		
		Ecuador	11	Iraq	1	Mexico	80	Philippines	4	Uruguay	1		

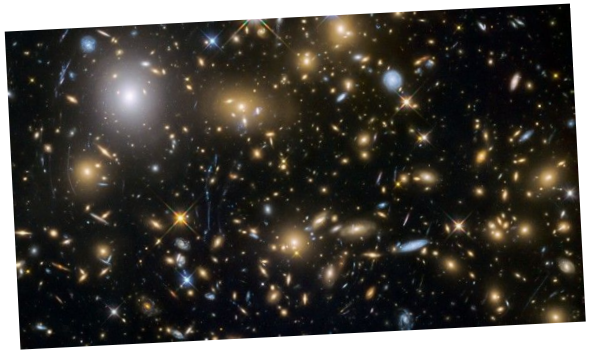
The life of the Universe

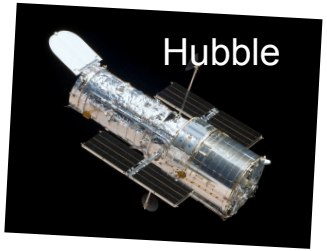
Our scientific challenge - understand the “just after” the Big Bang

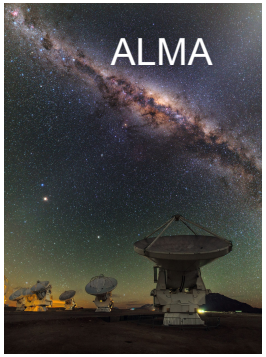


The scale of things (in cm)



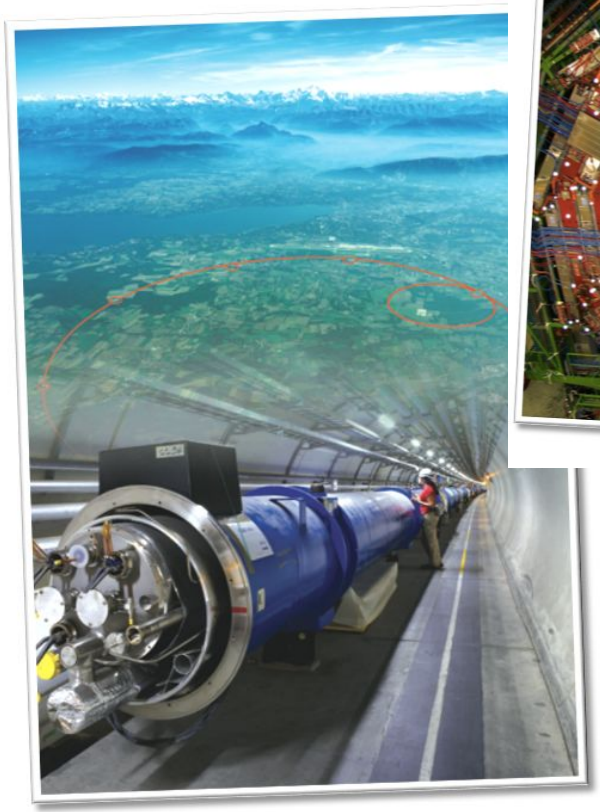


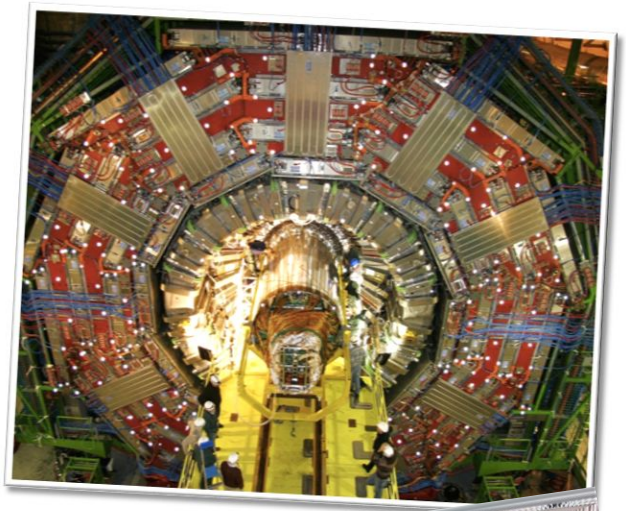




To study the laws of physics just after the Big Bang – links between particle physics, astrophysics and cosmology

The tools of the field





1. Accelerators:

To accelerate particles up to very high energies and make them collide

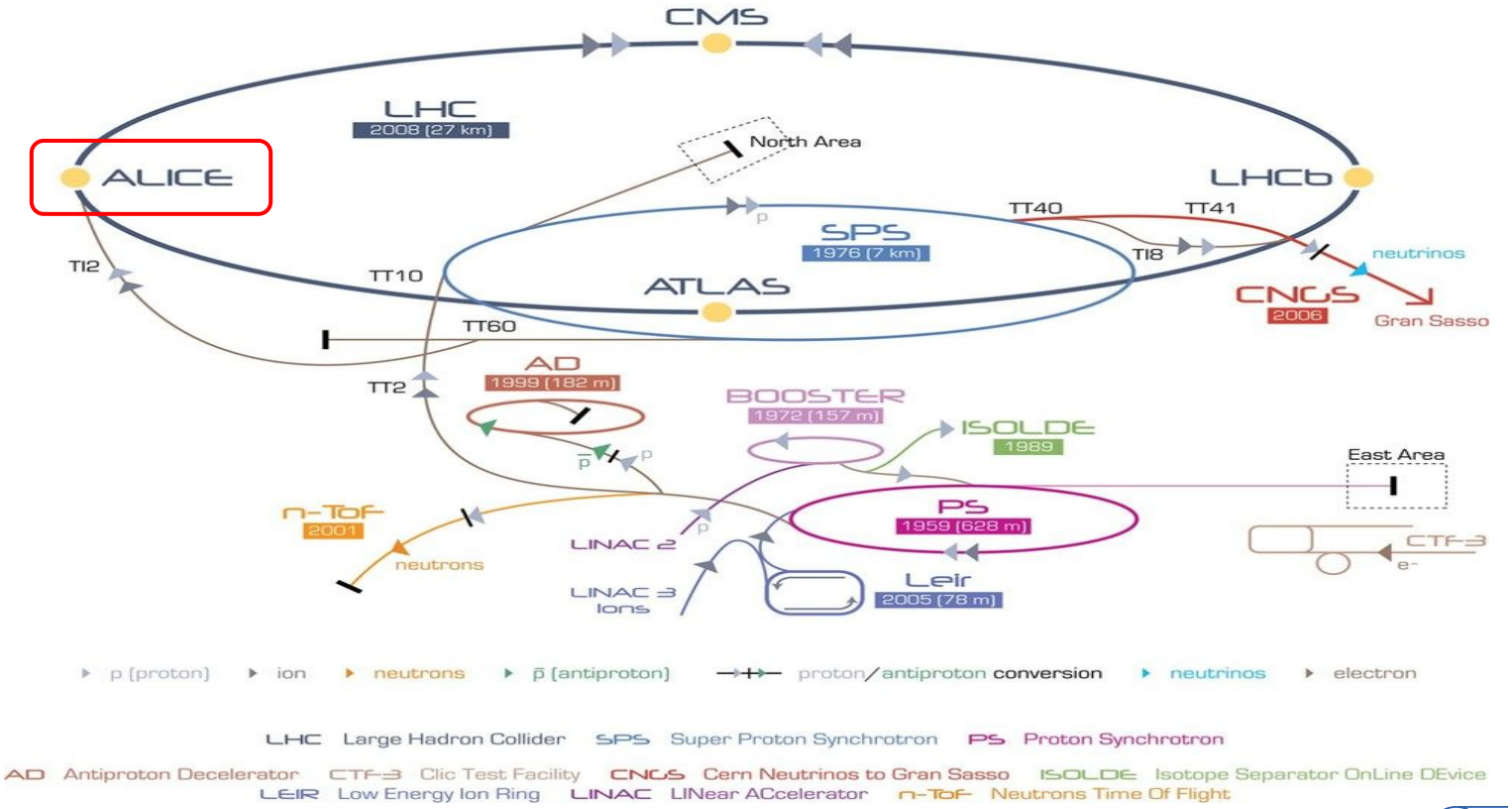
2. Detectors:

Gigantic instruments to record the information about the particles created in the collisions (trajectory, energy, electric charge...)

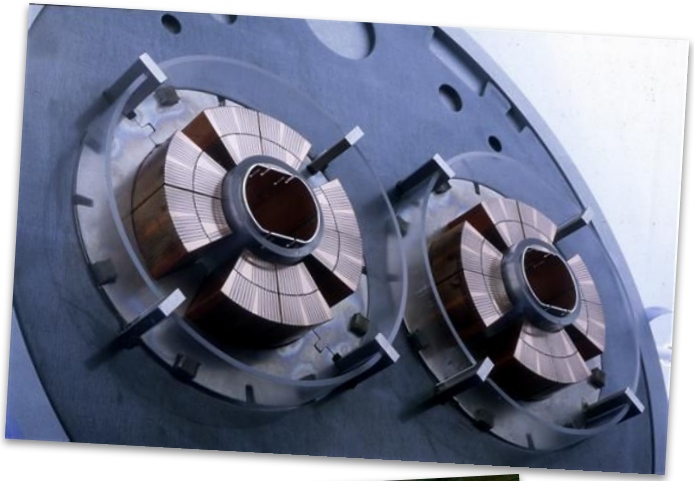
3. Computing:

To record, store, distribute and analyze the enormous quantity of data accumulated by the detectors

CERN accelerators complex

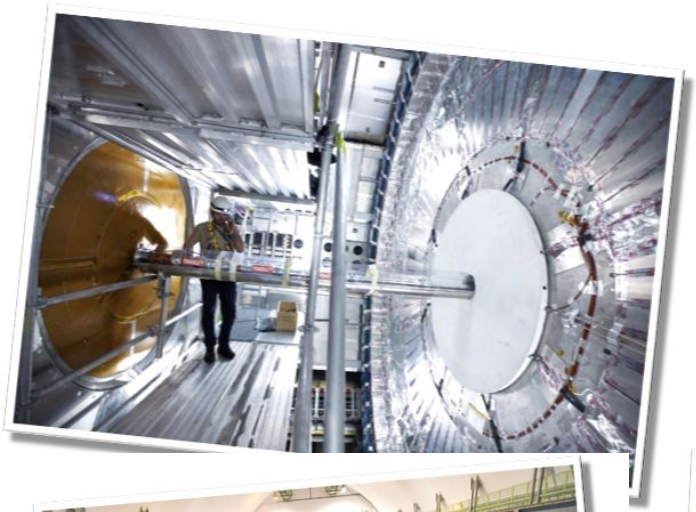


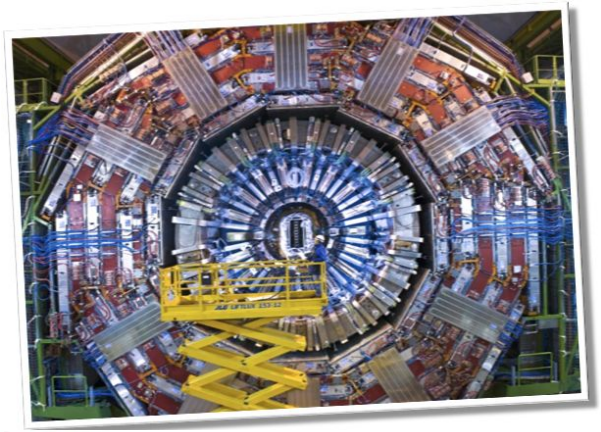
The LHC - the world's most powerful accelerator



- A 27 km long tunnel
- Thousands of superconductor electromagnets
- An ultra vacuum: 10x more empty than on the Moon
- The coldest place in the Universe: -271°C

The largest and most complex detectors

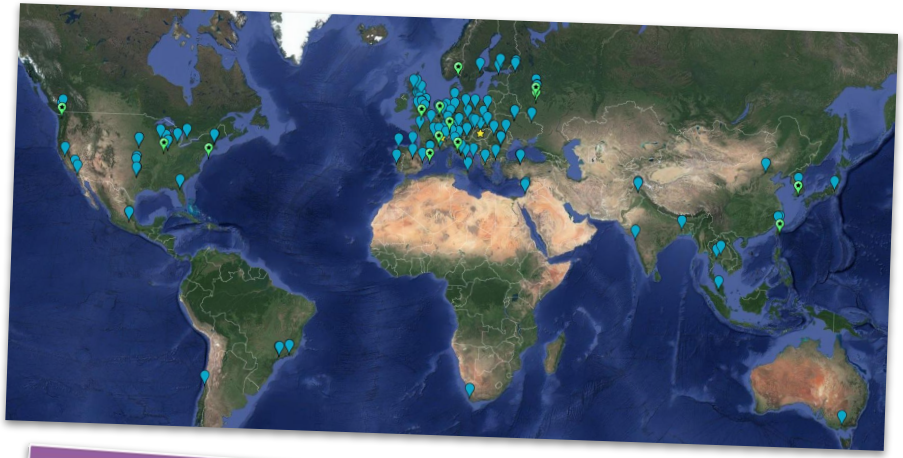


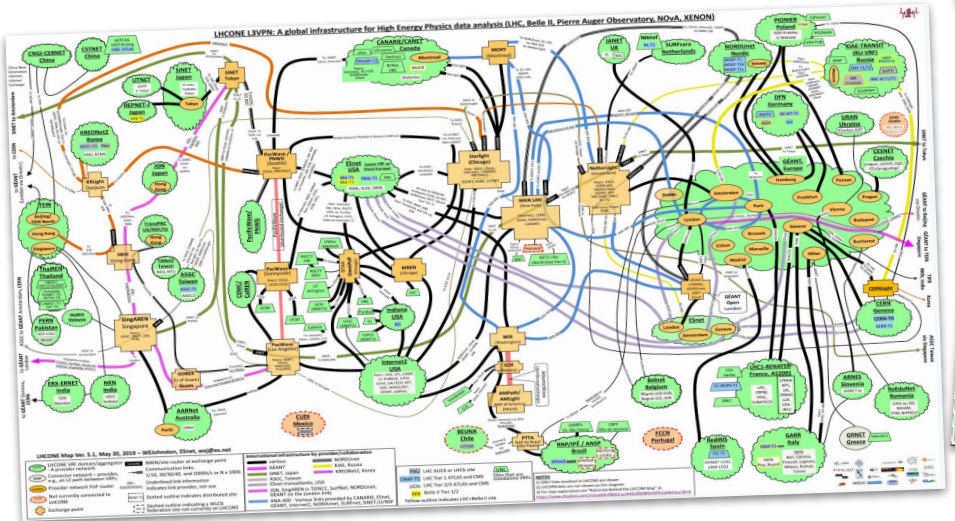


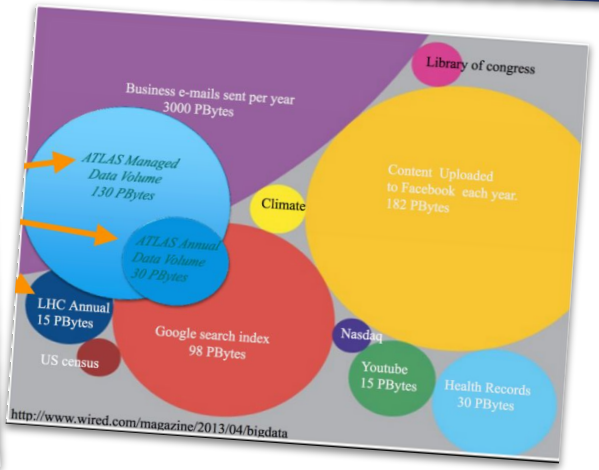
- Cathedrals dedicated to Science 100m underground
- 600 million collisions per second recorded by hundreds of millions of sensors
- Thousands of collaborators

The largest scientific computing grid

- ~1.4M CPU cores and 1.5EB of data on 170 sites in 42 countries, allowing 12 000 physicists around the world the power to process it the LHC data
- It runs over 2 million tasks per day and, at the end of the LHC's LS2, global transfer rates regularly exceeded 260 GB/s.





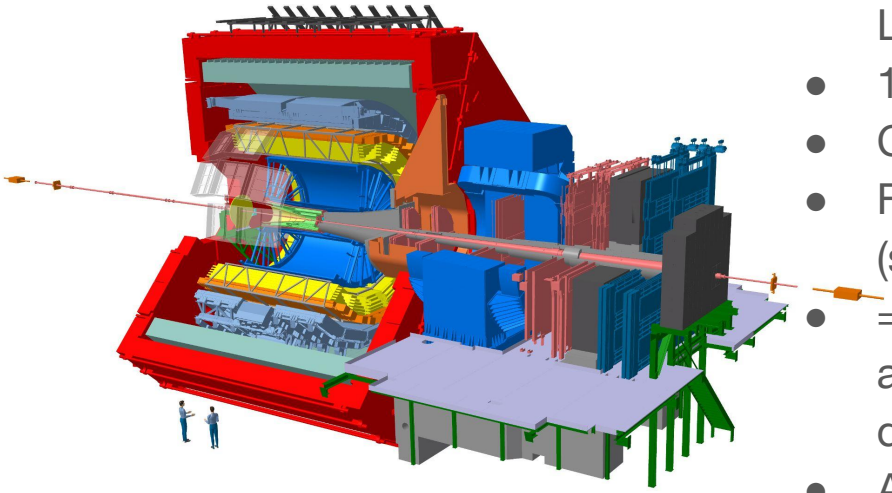


WLCG
Worldwide LHC Computing Grid

CERN

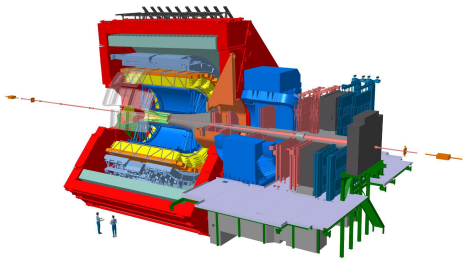
ALICE

ALICE upgrade in Run 3 (2022 - 2026)



- p-p and HI physics
- 10x integrated luminosity
  L~10nb^{-1} (B=0.5T) + 3nb^{-1} (B =0.2T)
- 100x event rate of Run 1/2, **10x more data**
- Continuous readout
- Focus on data compression and real time (synchronous) data reconstruction
- => Reasonable rates and data volumes after compression to storage and secondary data formats
- Adherence to ‘flat budget’ resources funding for data processing and analysis

Data flow and data rates



RAW data 3.5TB/s

First Level Processors (FLP)

STF - data from single FLP

600GB/s

Event Processing Nodes (EPN)

Compressed Time Frame (CTF) 10ms

100GB/s

Data buffer (92PB)

Custodial storage T0 ⅔ T1s ⅓

CTFs 8GB/s

CTF 20GB/s

T0/T1 Async. Processing, Analysis

Local storage

AODs, MCAODs ~10%

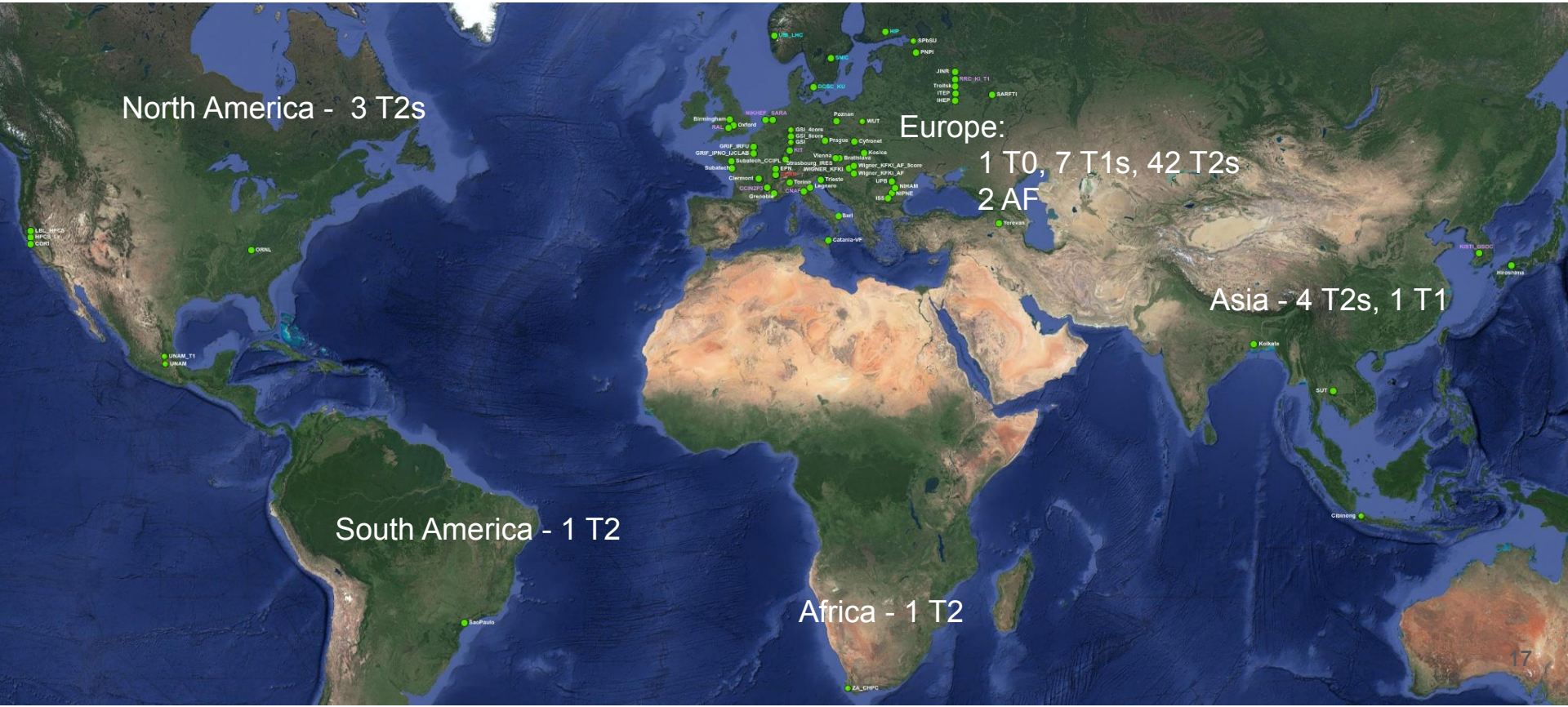
Analysis Facilities AODs, MCAODs

T2s MC production, Analysis

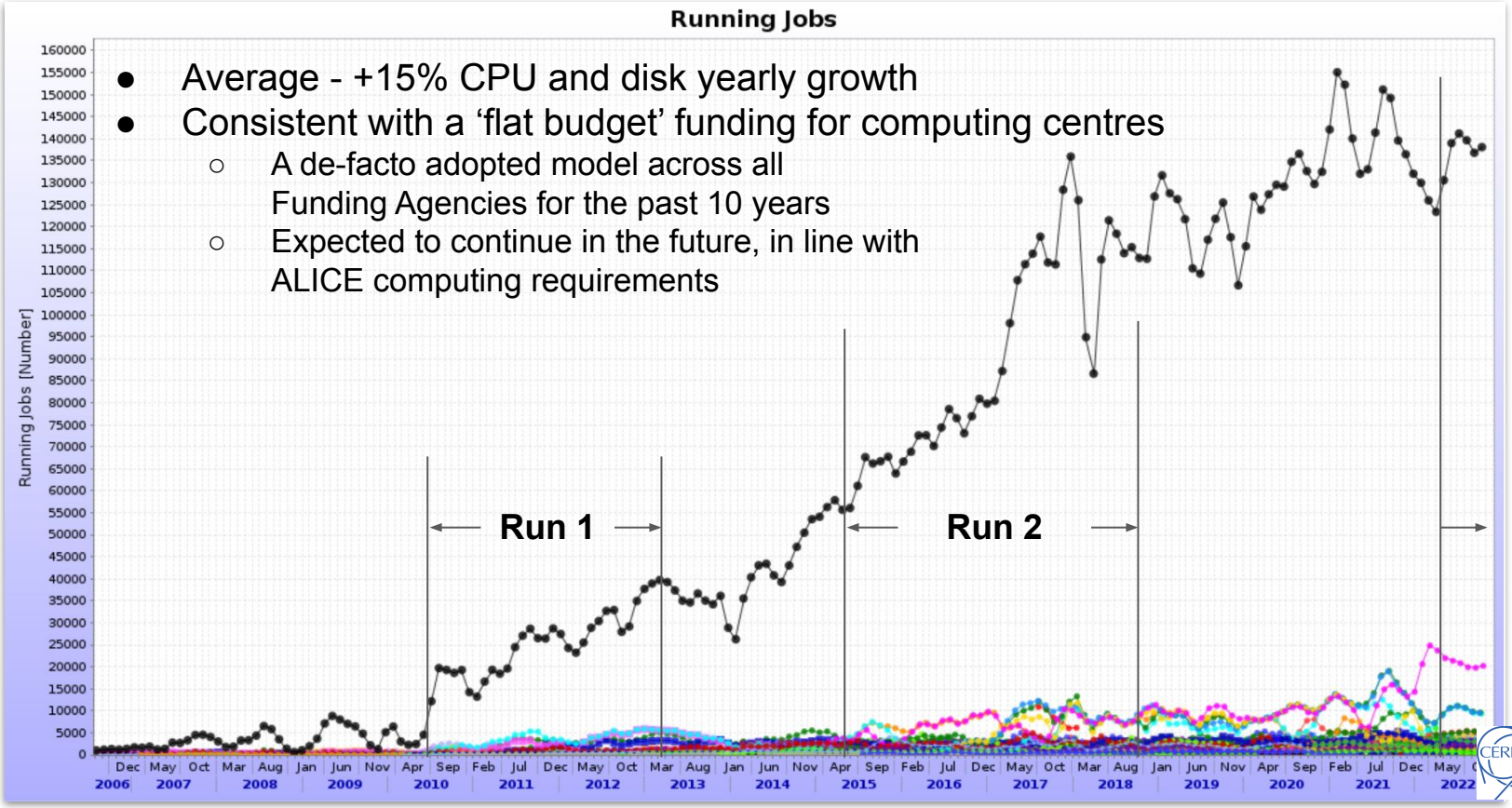
Local storage

AOD - Analysis Object Data
MCAOD - AOD from MC

The ALICE Grid - individual computing centres

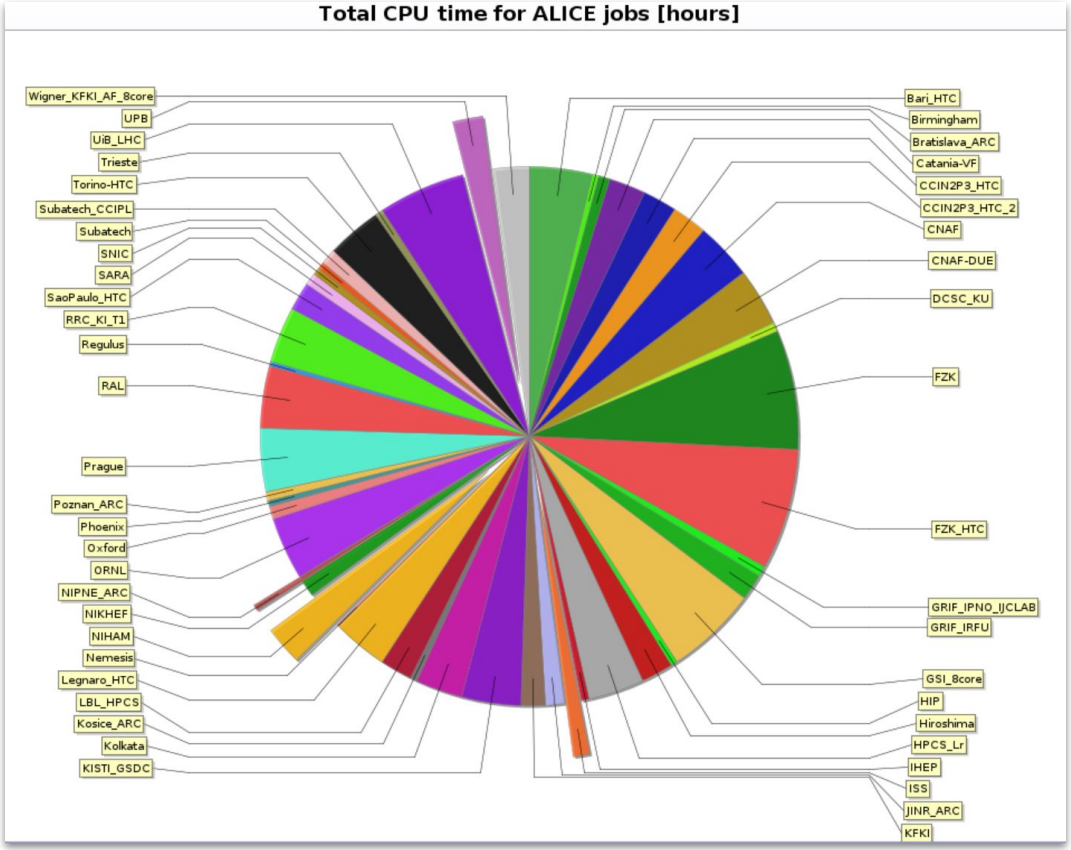


ALICE resources evolution



- Average - +15% CPU and disk yearly growth
- Consistent with a ‘flat budget’ funding for computing centres
  - A de-facto adopted model across all Funding Agencies for the past 10 years
  - Expected to continue in the future, in line with ALICE computing requirements

Romanian contribution to computing resources

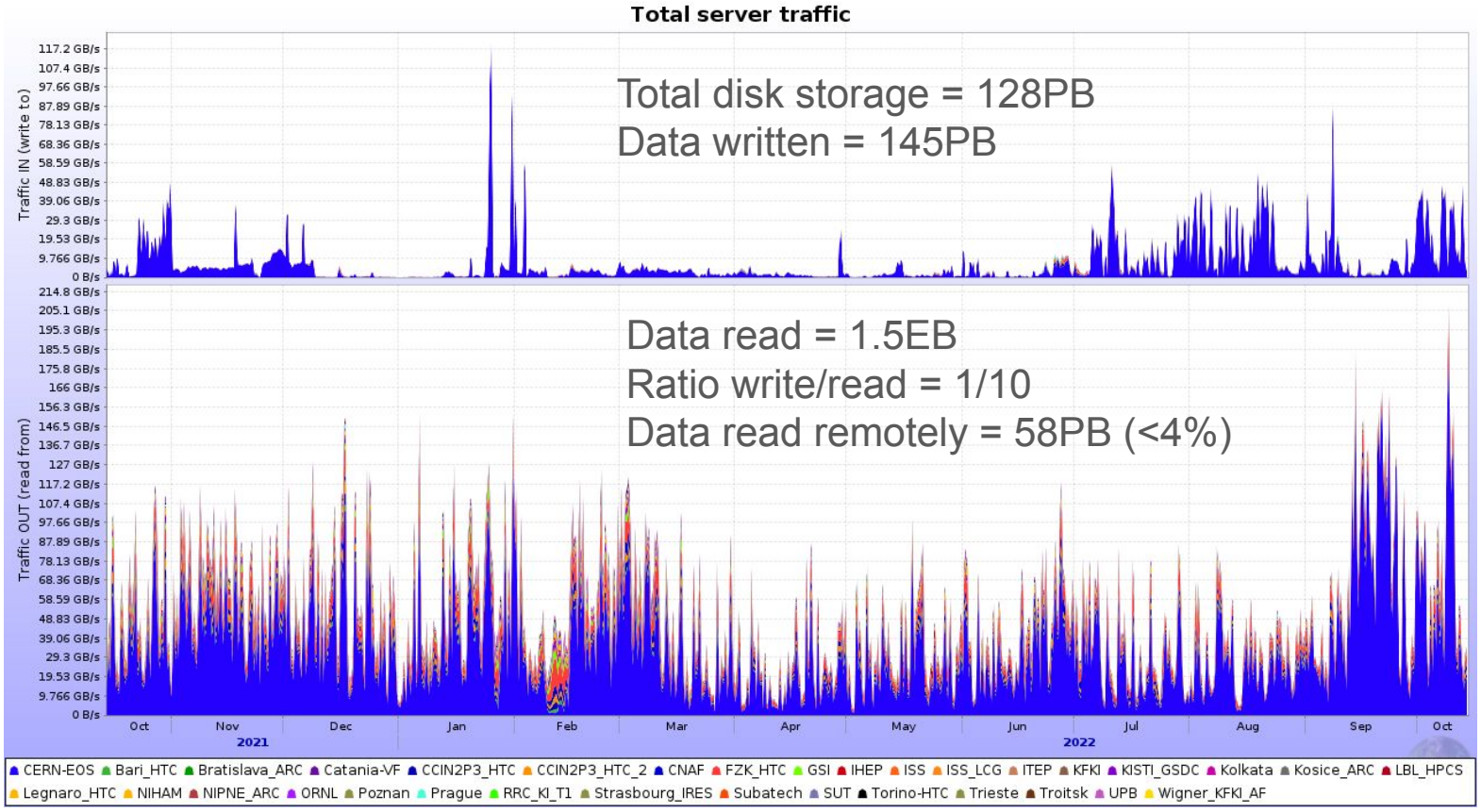


AliEn SE		Catalogue statistics			
AliEn name	Tier	Size	Used	Free	Usage
ALICE::ISS::EOS	2	1.911 PB	1.223 PB	704.6 TB	63.99%
ALICE::ISS::FILE	2	1.049 PB	790.6 TB	283.5 TB	73.61%
ALICE::NIHAM::EOS	2	3.4 PB	2.969 PB	440.9 TB	87.34%
ALICE::NIPNE::EOS	2	1014 TB	596.7 TB	417.3 TB	58.85%
ALICE::UPB::EOS	2	4.618 PB	3.913 PB	722.3 TB	84.73%
		11.97 PB	**9.46 PB**	**2.508 PB**	

9.3% of the disk capacity

3M CPU hours / last month
5.5% of the CPU power

Data access over last year



UPB contributions to ALICE computing

Grid monitoring framework (MonALISA), started some 20 years ago

- Ask your professors about it ;)

Production Grid site since 2017

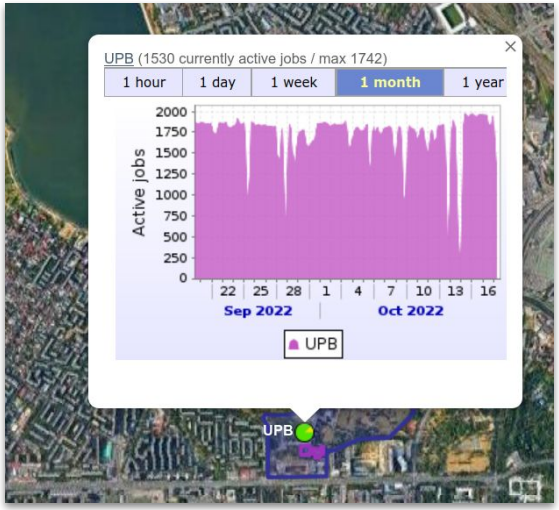
- ~2000 CPU cores and 4.6PB of highly reliable storage

Organizer of the Tier1/Tier2 ALICE workshop in 2019

Full member of the ALICE collaboration since 2020

Many opportunities for student projects at all levels

- GSoC, Bachelor and Master, PhD



CERN collaboration opportunities

Google Summer of Code

- many projects proposed by the organization

CERN summer student

- 2 to 3 months internship, apply in Dec-Jan 2023

Bachelor and master projects

- Longer term involvement

Technical student

- One year internship at CERN, while still student (short term also possible)

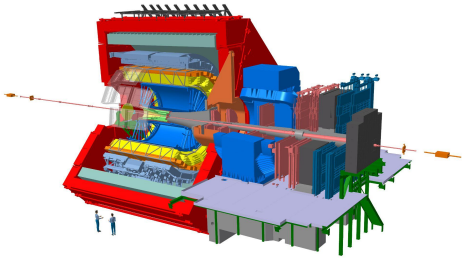
Doctoral student

- 2 options: based in UPB or a CERN position

Fellow, Staff

- CERN positions, function of experience - apply directly to them

UPB projects



Monitoring and accounting
Cristian Mărgineanu

Grid central services

File catalogue optimizers
Iuliana Brînzoi

MonteCarlo scheduling optimizations
Elena Mihăilescu

T0/T1 Async. Processing, Analysis

T2s MC production, Analysis

CTF
20GB/s

Custodial storage
T0 ⅔, T1s ⅓

CTFs
8GB/s

Experiment data management tools
Sergiu Weisz

Local storage

Storage & file crawler
Adrian Negru

Local storage

Real-time calibration data distribution
Daniel-Florin Dosaru

450 FLP and EPN servers

epn2eos
Alice-Florenţa Şuiu

100GB/s

Data buffer (92PB)

Analysis Facilities

CVMFS benchmark & profiling
Răzvan-Nicolae Vîrtan

HPC center integration
Sergiu Weisz & Mihai Popescu