ALICE Day@UPB
Oct 2024
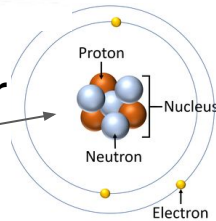
Costin.Grigoras@cern.ch

ANI CERN

1954-2024

CERN is founded after the WWII

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

CERN = Conseil Européen pour la Recherche Nucléaire

SUISSE
FRANCE

CMS

LHCb

CERN Prévessin

CERN Meyrin

ATLAS

SPS 7 km

ALICE

LHC 27 km

ALICE

3

Today - the world largest laboratory for particle physics

Member States of CERN

Member States (date of accession)

- Austria (1959)
- Belgium (1953)
- Bulgaria (1999)
- Czech Republic (1993)
- Denmark (1953)
- Finland (1991)
- France (1953)
- Germany (1953)
- Greece (1953)
- Hungary (1992)
- Israel (2014)
- Italy (1953)
- Netherlands (1953)
- Norway (1953)
- Poland (1991)
- Portugal (1986)
- Romania (2016)
- Serbia (2019)
- Slovakia (1993)
- Spain (1961-1968, 1983-)

- Sweden (1953)
- Switzerland (1953)
- United Kingdom (1953)

States in accession to Membership and Associate Members

- Croatia (2019)
- Cyprus (2016)
- India (2017)
- Lithuania (2018)
- Pakistan (2015)
- Slovenia (2017)
- Turkey (2015)
- Ukraine (2016)

Yearly budget:
~ 1400 MCHF

Personnel:
~2660   Staff members
~840   Fellows
~350   Students
~12000   Users

Observers:
EU, USA, Japan, UNESCO

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Distribution of All CERN Users by Nationality on 27 January 2020

MEMBER STATES — 7 149

Country	Users
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

ASSOCIATE MEMBERS IN THE PRE-STAGE TO MEMBERSHIP — 54

Country	Users
Cyprus	21
Slovenia	33

ASSOCIATE MEMBERS — 770

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

OBSERVERS — 2 506

Country	Users
Japan	274
Russia	1 126
USA	1 106

OTHERS — 1 822

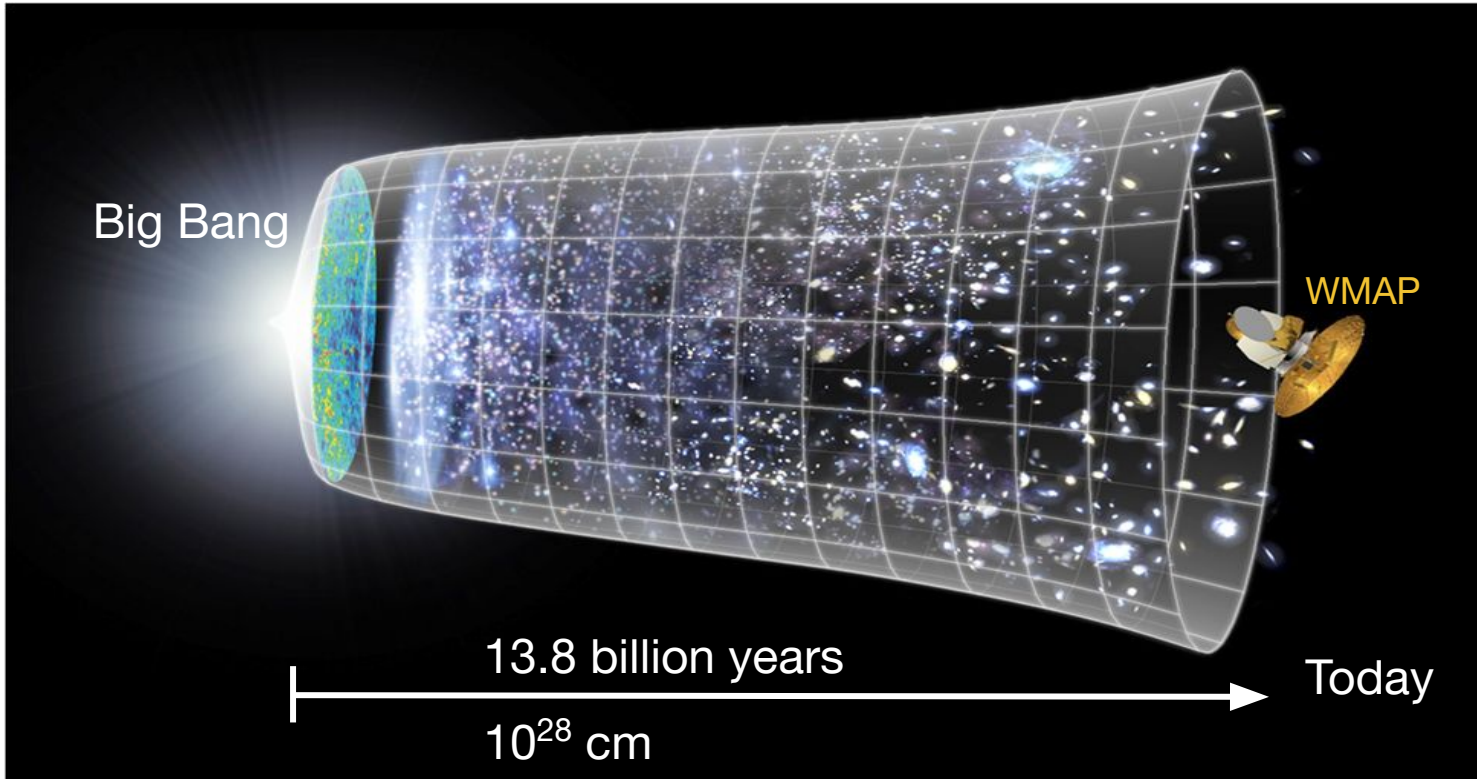| Country	Users	Country	Users	Country	Users	Country	Users	Country	Users	Country	Users
		Bolivia	2	Egypt	26	Ireland	14	Montenegro	8	Saint Kitts and Nevis	1	Uzbekistan	3
		Bosnia & Herzegovina	2	El Salvador	1	Jamaica	1	Morocco	26			Venezuela	10
		Bostwana	1	Estonia	16	Jordan	2	Myanmar	1	Saudi Arabia	2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

CERN   ALICE

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The life of the Universe

Our scientific challenge - understand the "just after" the Big Bang

Big Bang

WMAP

13.8 billion years

10^{28} cm

Today

The scale of things (in cm)

Big Bang

10^{-32} 10^{-28} 10^{-24} 10^{-20} 10^{-16} 10^{-12} 10^{-8} 10^{-4}

Proton
Atom

10^{4} 10^{8} 10^{12} 10^{16} 10^{20} 10^{24} 10^{28}

Earth radius

Earth to Sun distance

Galaxies radius

Universe

cm

Quarks
u
u d
Proton
Neutron
Nucleus
Electron
Atom
Molecule
Matter

Hubble

ALMA

AMS

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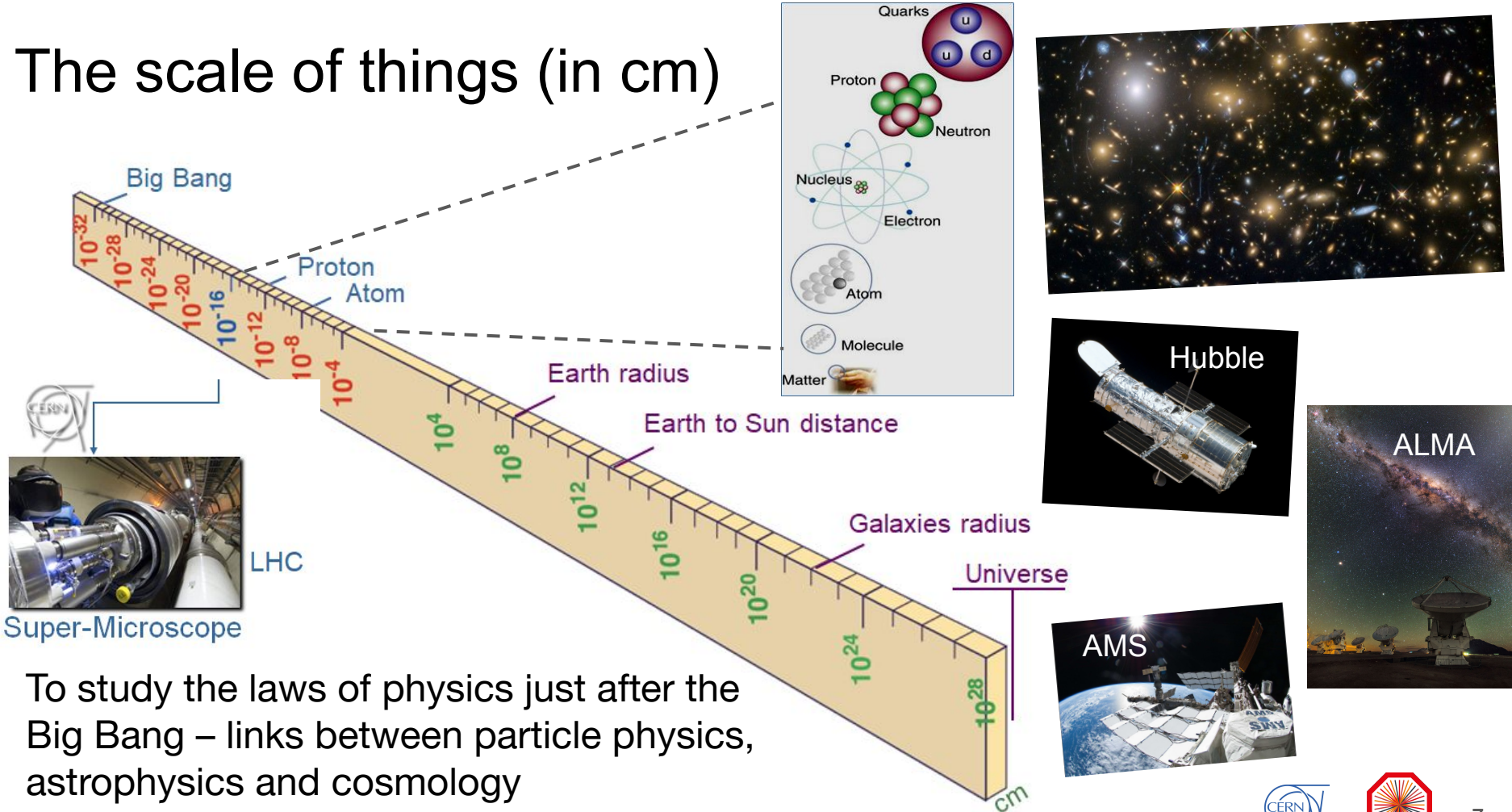
To study the laws of physics just after the Big Bang – links between particle physics, astrophysics and cosmology

ALICE

The tools of the field
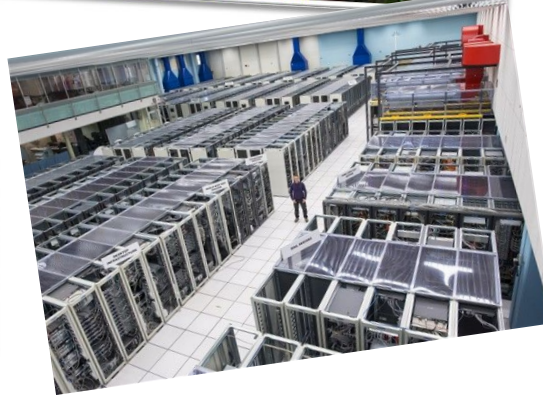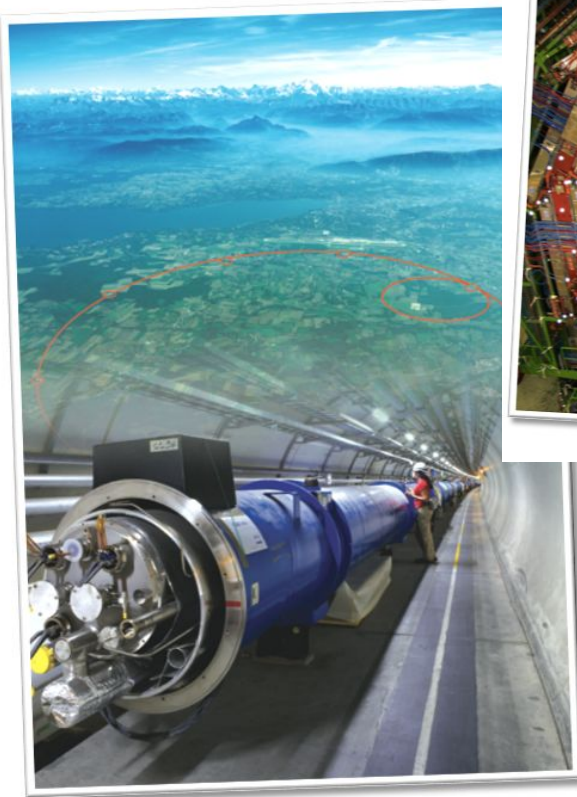
1. Accelerators:

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
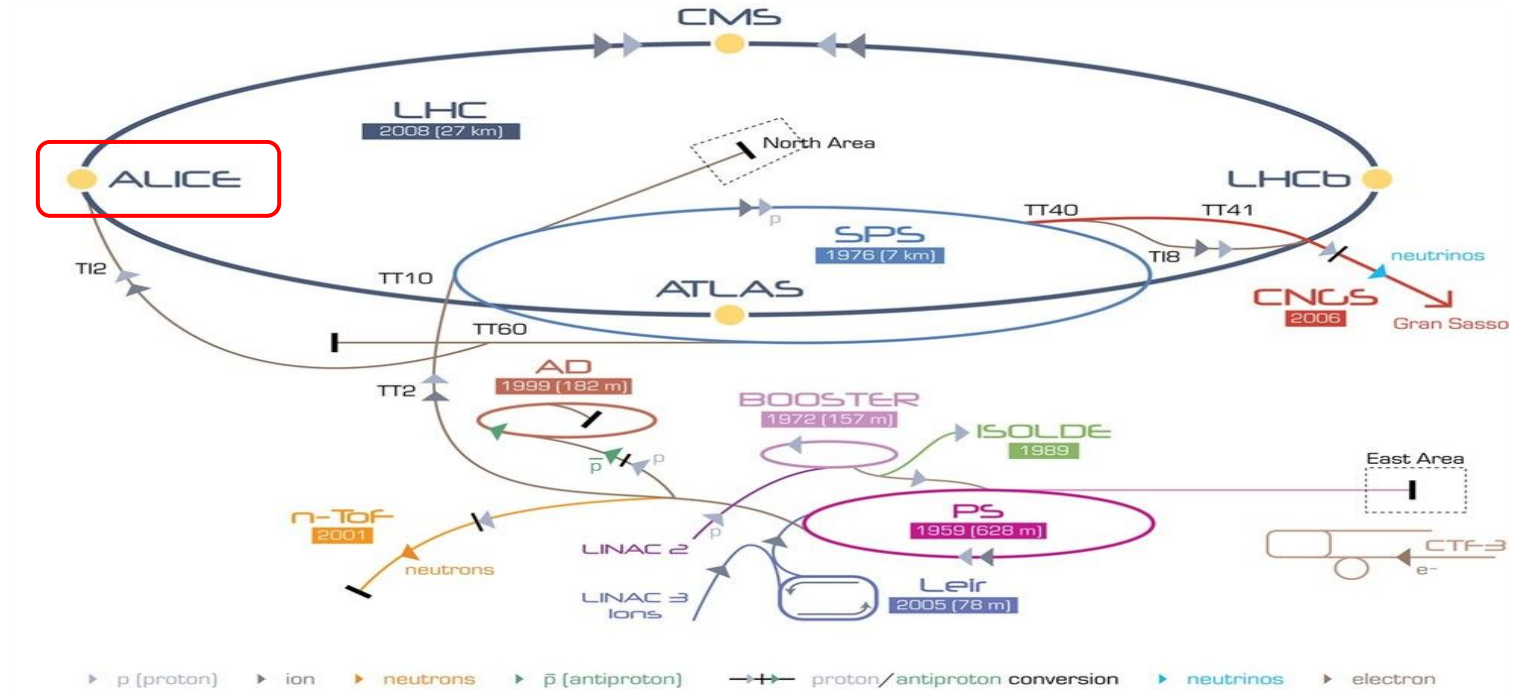
The LHC - the world's most powerful accelerator
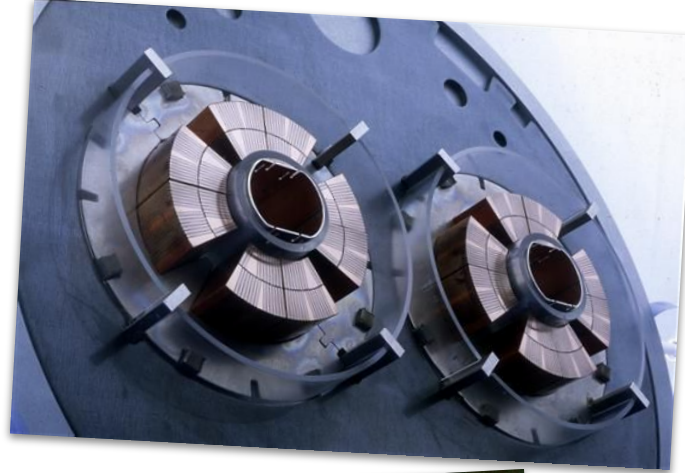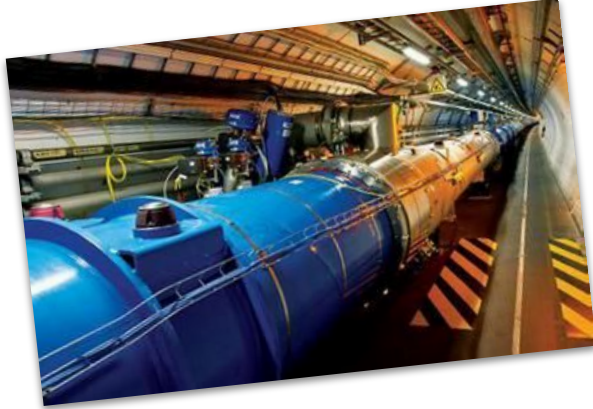
- A 27 km long tunnel

- 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
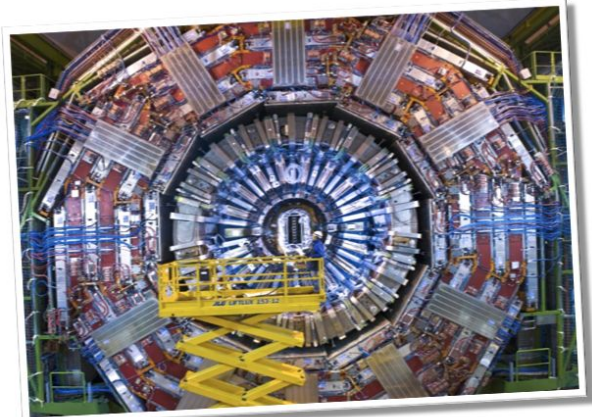
- Cathedrals dedicated to Science 100m underground

- 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.
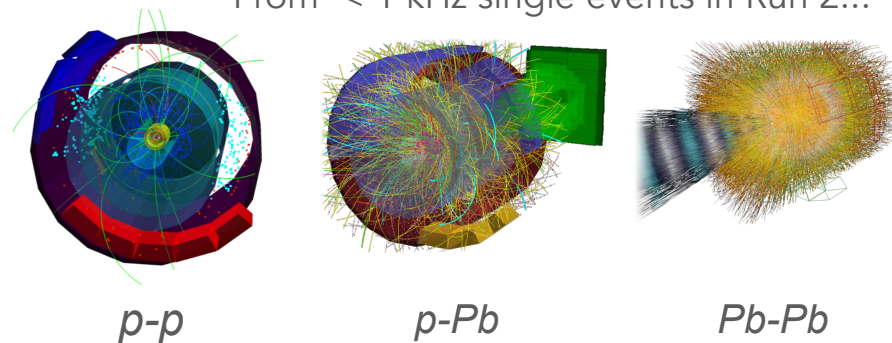

http://www.wired.com/magazine/2013/04/bigdata
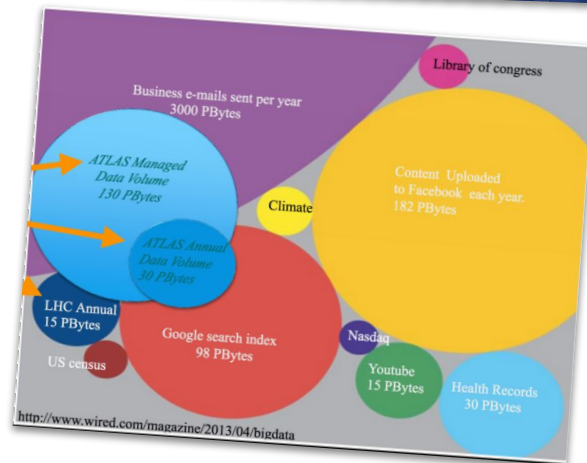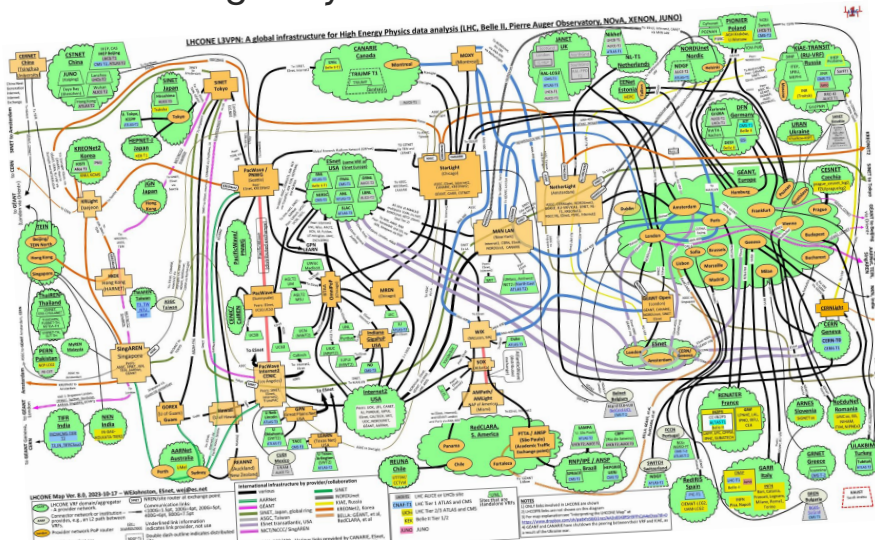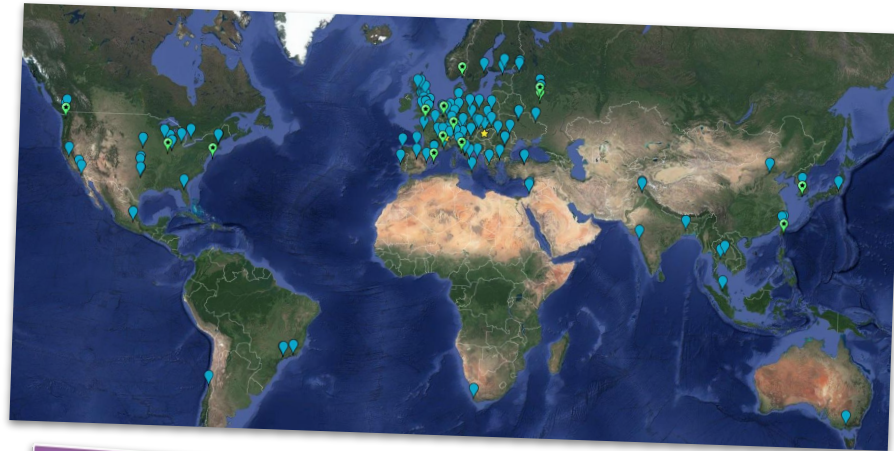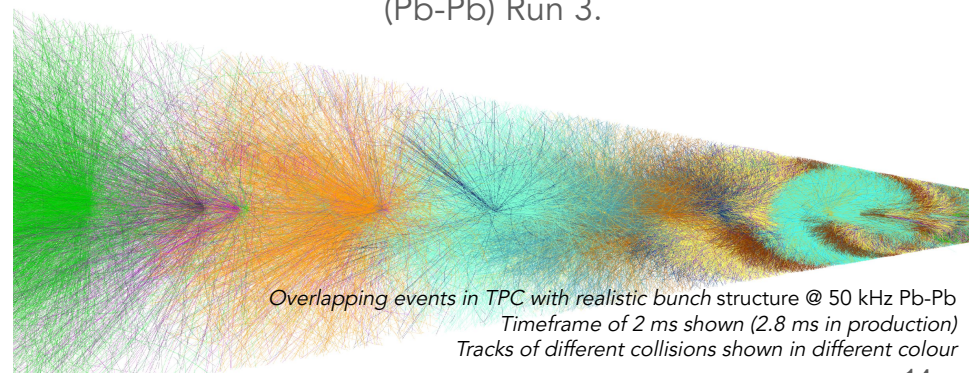
LHC schedule

Pb-Pb collisions
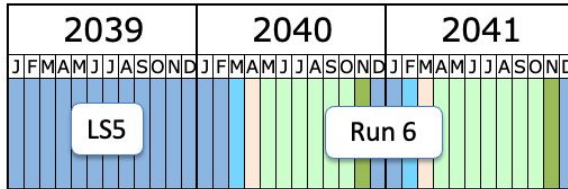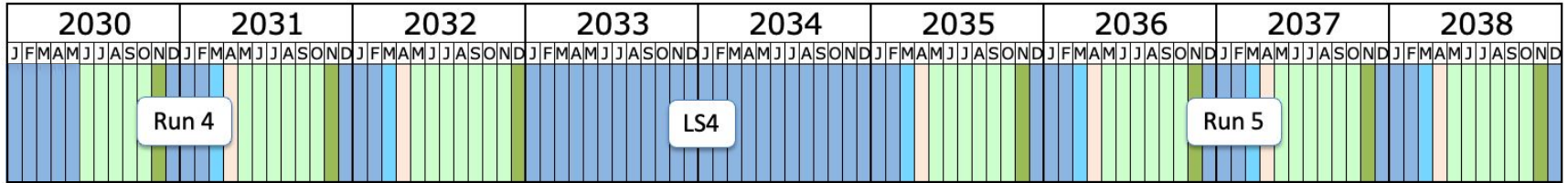
Challenges for ALICE in Run 3

- **Completely new detector readout** and **substantial detector upgrades:** new ITS, MFT, FIT. New GEM for TPC readout.

- Reconstruct TPC data in **continuous readout** in combination with triggered detectors.

- **Reconstruct O(100x) more** events online.

- **Store O(100x)** more events (needs factor 36x for TPC compression). Cannot store all raw data, use **GPUs to do compression online**.

- WLCG "**flat budget**" scenario (4x more resources over 10 years, for 100x more events). **Use online GPU farm offline to speedup processing**.

From < 1 kHz single events in Run 2...

p-p *p-Pb* *Pb-Pb*

...to 50 kHz of continuous readout data in (Pb-Pb) Run 3.

Overlapping events in TPC with realistic bunch structure @ 50 kHz Pb-Pb
Timeframe of 2 ms shown (2.8 ms in production)
Tracks of different collisions shown in different colour

ALICE in Run 3: The O^2 Project
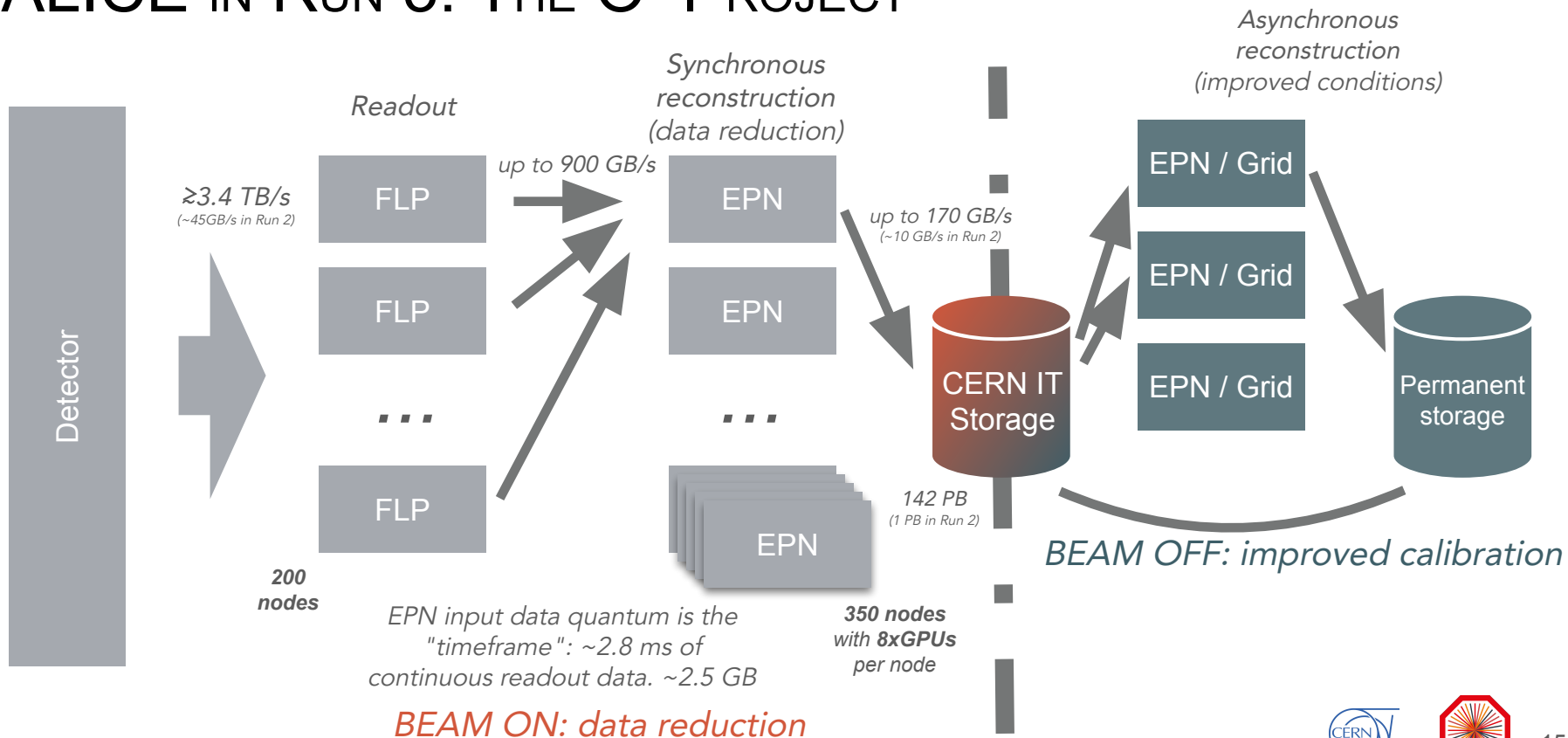
Detector

≥3.4 TB/s
(~45GB/s in Run 2)

Readout

FLP

FLP

...

FLP

200 nodes

up to 900 GB/s

Synchronous reconstruction (data reduction)

EPN

EPN

...

EPN

EPN input data quantum is the "timeframe": ~2.8 ms of continuous readout data. ~2.5 GB

350 nodes with 8xGPUs per node

BEAM ON: data reduction

up to 170 GB/s
(~10 GB/s in Run 2)

CERN IT Storage

142 PB
(1 PB in Run 2)

Asynchronous reconstruction (improved conditions)

EPN / Grid

EPN / Grid

EPN / Grid

Permanent storage

BEAM OFF: improved calibration

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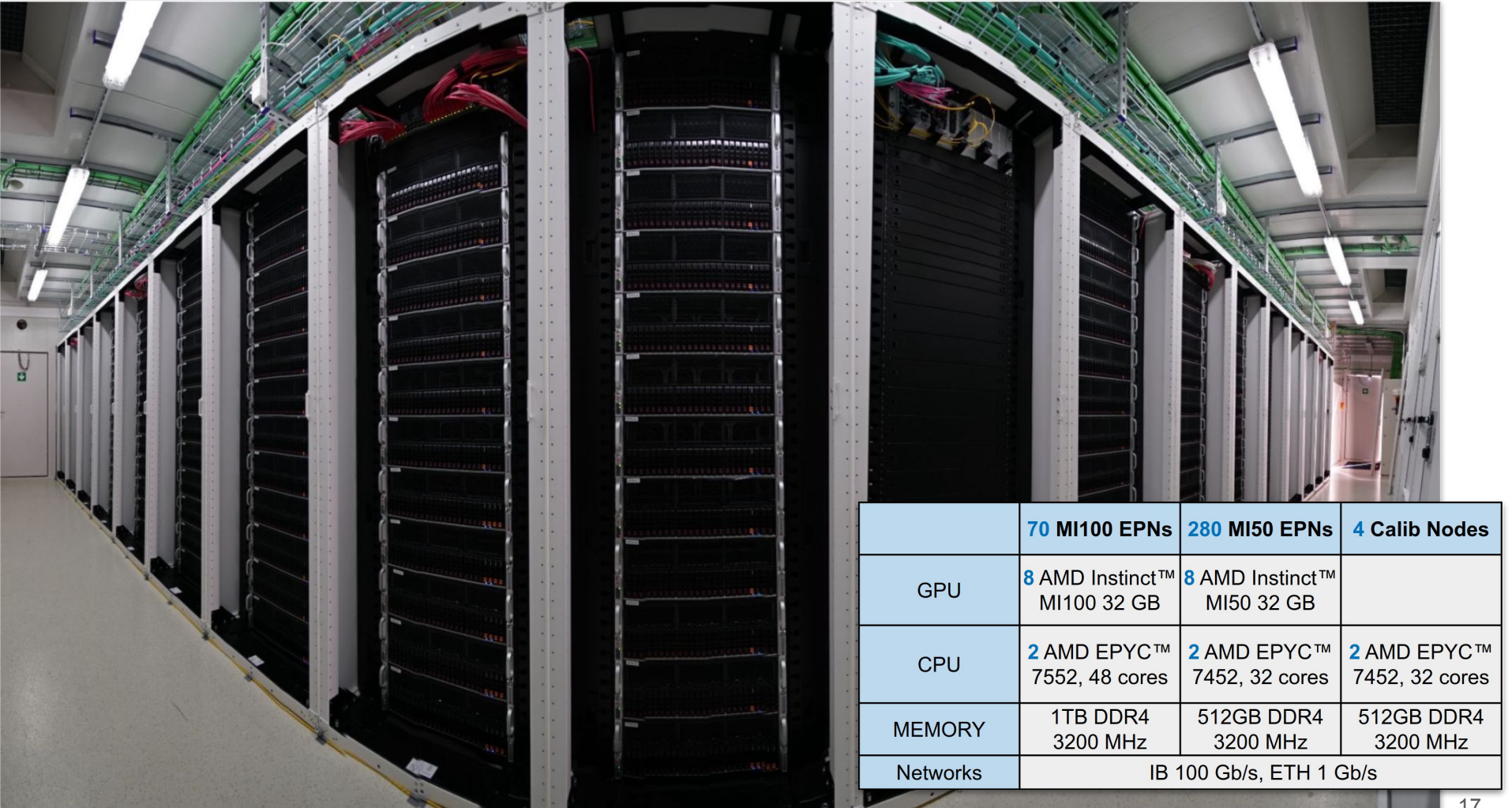
	70 MI100 EPNs	280 MI50 EPNs	4 Calib Nodes
GPU	8 AMD Instinct™ MI100 32 GB	8 AMD Instinct™ MI50 32 GB	
CPU	2 AMD EPYC™ 7552, 48 cores	2 AMD EPYC™ 7452, 32 cores	2 AMD EPYC™ 7452, 32 cores
MEMORY	1TB DDR4 3200 MHz	512GB DDR4 3200 MHz	512GB DDR4 3200 MHz
Networks	IB 100 Gb/s, ETH 1 Gb/s		

Data flow and data rates

RAW data   **3.4 TB/s**

First Level Processors (FLP)

STF - data from single FLP

900 GB/s

Event Processing Nodes (EPN)

Compressed Time Frame (CTF) 2.8 ms

170 GB/s

Data buffer (142 PB)

Custodial (tape) storage T0 ⅔ + T1s ⅓

CTFs **10 GB/s**

CTF **20 GB/s**

T0/T1 Async. Processing, Analysis

Local storage

Local storage

T2s MC production, Analysis

AODs, MCAODs ~10%

Analysis Facilities AODs, MCAODs

AOD - Analysis Object Data
MCAOD - AOD from MC

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The ALICE Grid - individual computing centres

North America - 3 T2s

Europe:
1 T0, 7 T1s, 42 T2s
2 AF

Asia - 4 T2s, 1 T1

South America - 1 T2

Africa - 1 T2
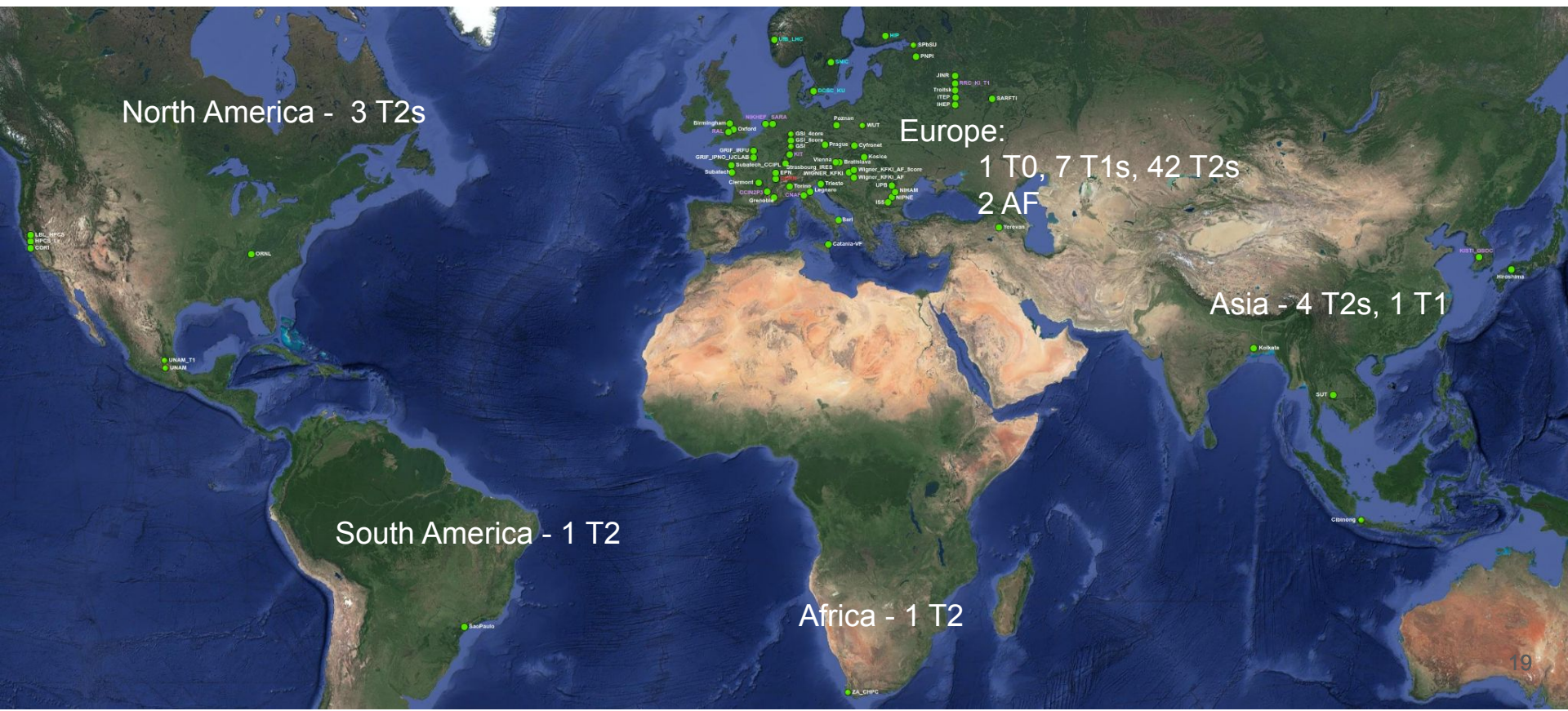
The ALICE Grid middleware, JAliEn

Central Services

Sites and Users

LDAP

CA

Server endpoints

Task Queue
File Catalogue
Transfers
Monitoring &
Accounting

MonALISA collector

VoBox
Computing Element
MonALISA aggregator

Site
BatchQueue

Worker nodes

Disk storage

Tape
archives
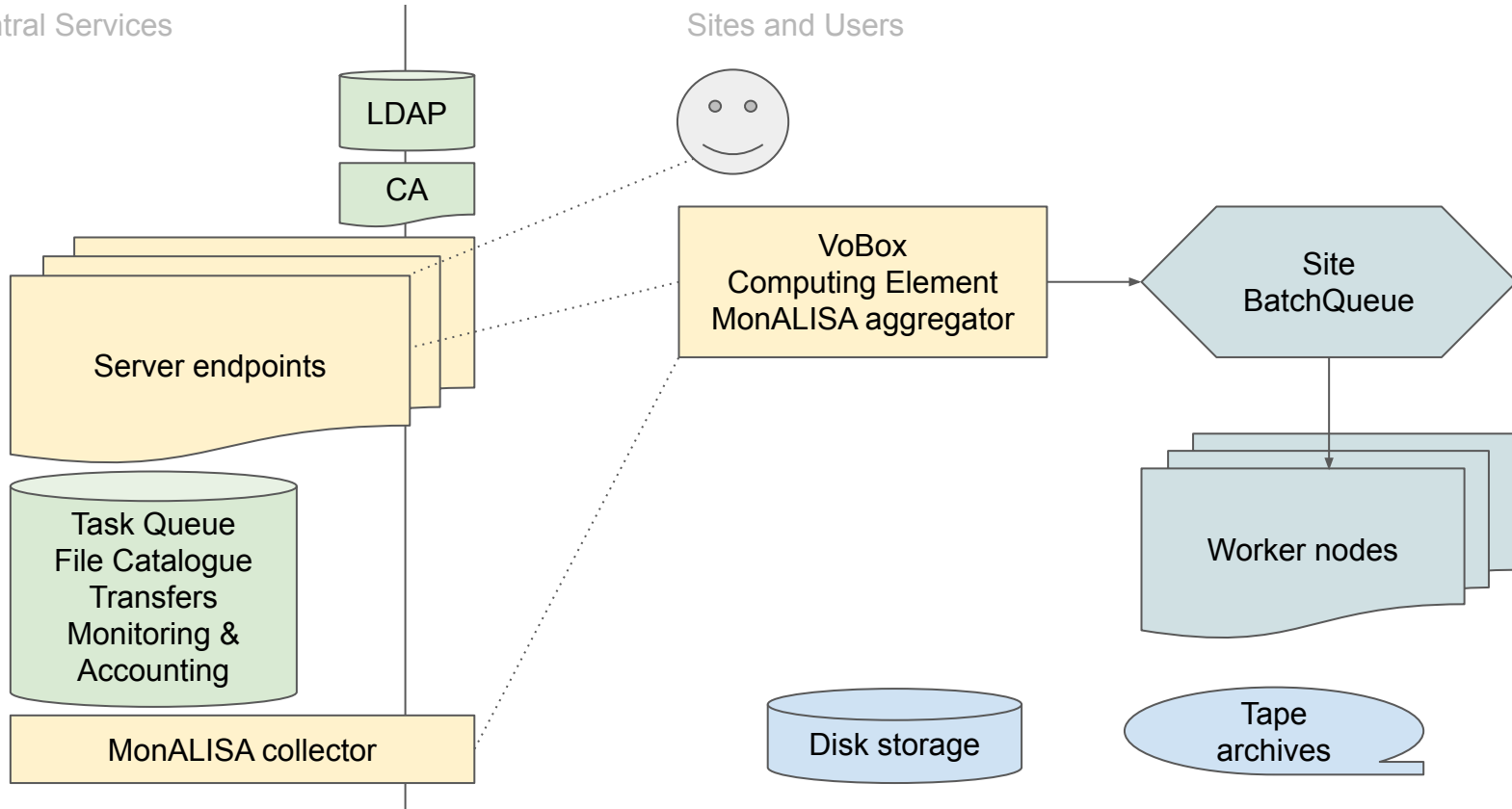
The ALICE Grid - some numbers

Central Services

Sites and Users

LDAP

CA

2750

18x

Server endpoints

VoBox
Computing Element
MonALISA aggregator   80x

Site
BatchQueue

Task Queue
File Catalogue
Transfers
Monitoring &
Accounting

10 TB MySQL &
PostgreSQL

8000x

Worker nodes

200k CPU cores

MonALISA collector

46x, 330 PB, 2.3 B files

9x, 150 PB, 110 M files

Disk storage

Tape
archives

21
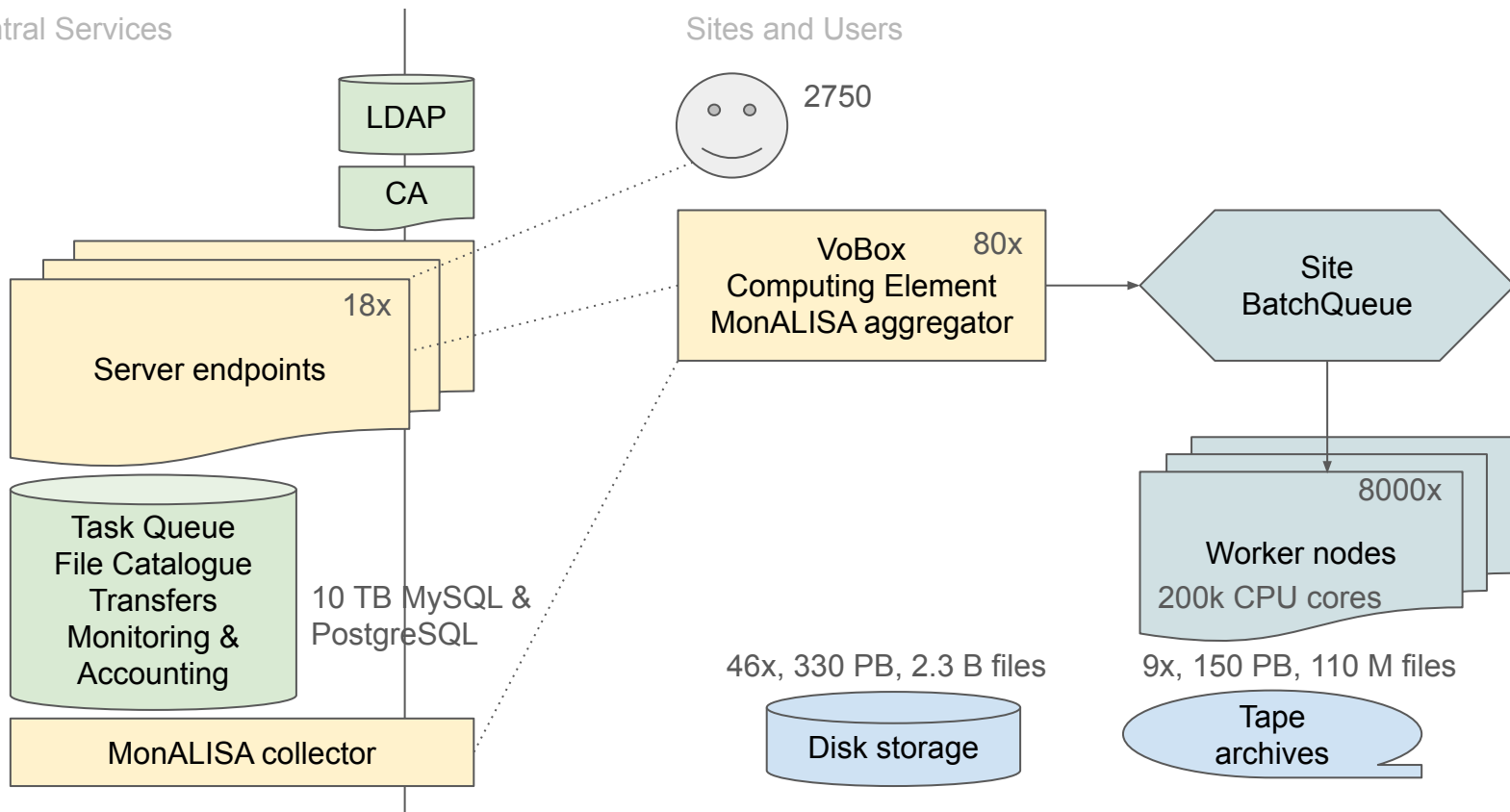
ALICE resources evolution

Total allocated cores per site

- 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 15 years
  - Expected to continue in the future, in line with
    ALICE computing requirements

Run 1

Run 2

Run 3
(to mid 2026)
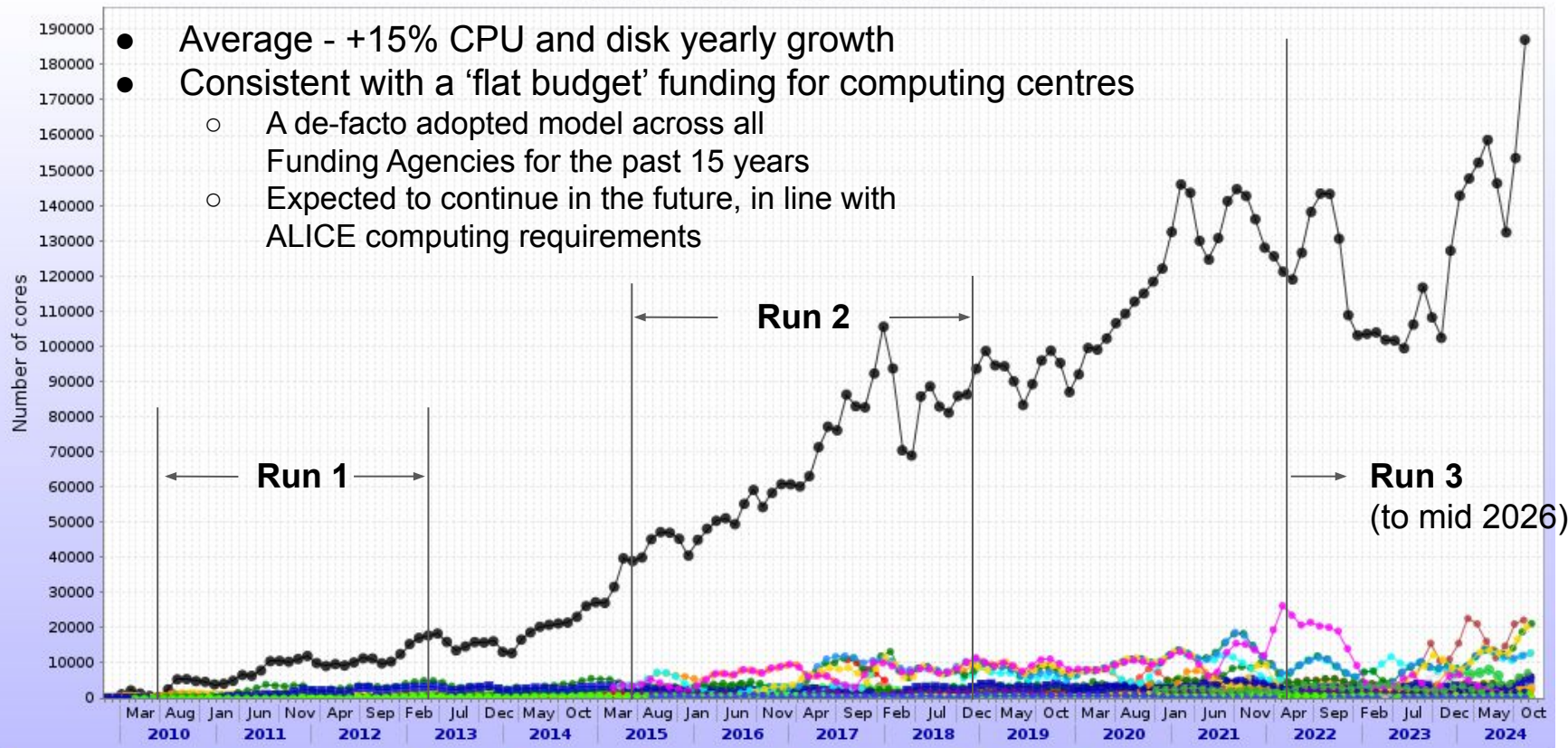
Romanian contribution to computing resources
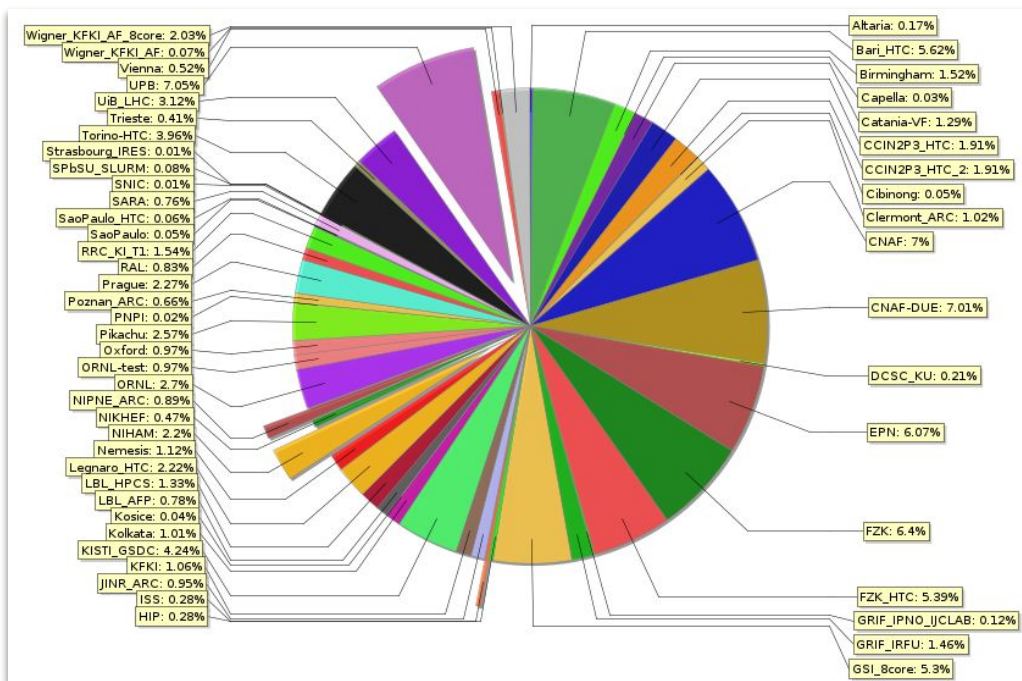
AliEn SE		Catalogue statistics			
AliEn name	**Tier**	**Size**	**Used**	**Free**	**Usage**
ALICE::ISS::EOS	2	5.637 PB	4.149 PB	1.488 PB	73.6%
ALICE::NIHAM::EOS	2	3.397 PB	3.034 PB	371.7 TB	89.31%
ALICE::NIPNE::EOS	2	1.011 PB	709.8 TB	325.8 TB	68.54%
ALICE::UPB::CCDB	2	100 TB	2.673 TB	97.33 TB	2.673%
ALICE::UPB::EOS	2	8.242 PB	7.097 PB	1.145 PB	86.11%
		18.39 PB	**14.98 PB**	**3.409 PB**	

~10% of the Tier 1 & Tier 2
resources (CPU and disk storage)

UPB contributions to ALICE computing

Grid monitoring framework (MonALISA), started some 20+ years ago
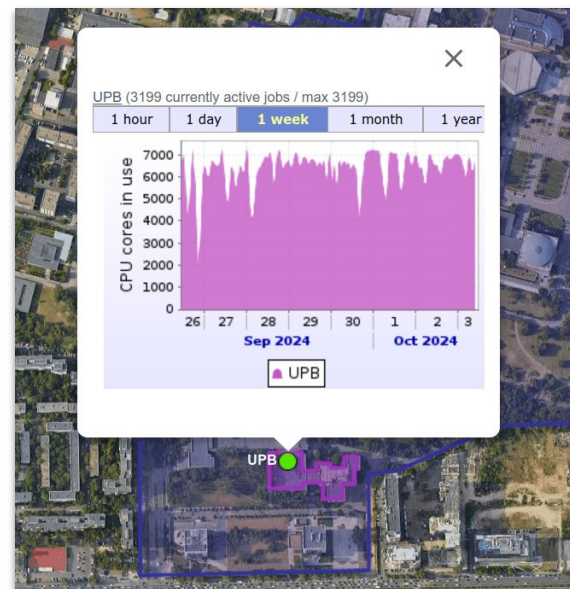> Ask your professors about it ;)

Production Grid site since 2017
> ~7000 CPU cores and 8.2 PB of disk 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 and OpenLab summer student

    2 to 3 months internship, apply in Dec-Jan

Bachelor and master projects

    Longer term involvement

Technical student

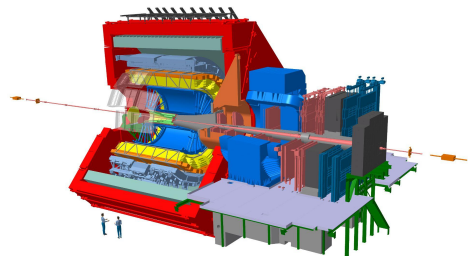   One year internship at CERN, while still student (short term also possible)

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
Mateea Popescu

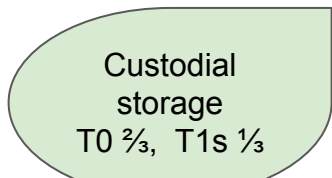Grid central services

File catalogue optimizers
Iuliana Brînzoi

Job scheduling optimizations
Elena Mihăilescu

T0/T1 Async. Processing, Analysis

CTF
20 GB/s

T2s MC production, Analysis

Storage integrity check
Andreea Prigoreanu

Custodial storage
T0 ⅔, T1s ⅓

CTFs
10 GB/s

Data management tools
Sergiu Weisz

Local storage

Storage & file crawler
Adrian Negru

Local storage

Real-time calibration data distribution
Daniel-Florin Dosaru

550 FLP and EPN servers

epn2eos
Alice-Florenţa Şuiu

170 GB/s

Data buffer (140PB)
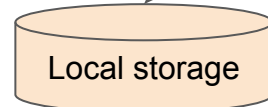
Analysis Facilities

CVMFS benchmark & profiling
Răzvan-Nicolae Vîrtan
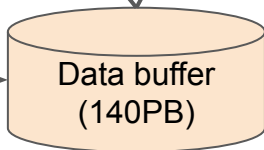
HPC center integration
Sergiu Weisz & Mihai Popescu

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