LA A 70-A ANIVERSARE A CERN

Mihnea Dulea
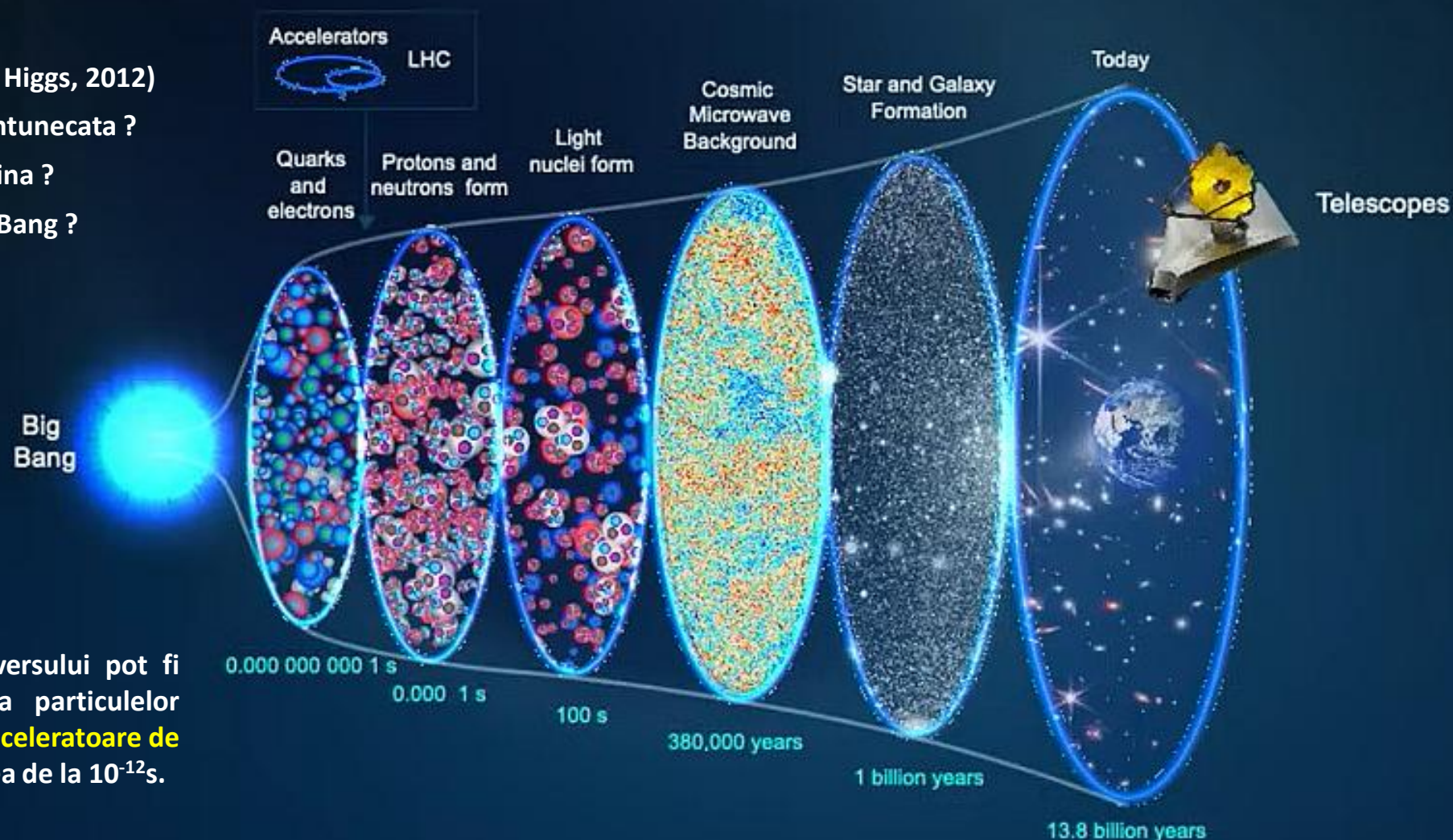
Departament Fizica Computationala si Tehnologia Informatiei (DFCTI)
INCD pentru Fizica si Ingineria Nucleara 'Horia Hulubei' (IFIN-HH)
Magurele

"*La inceput a fost Big Bang-ul...*"

The Evolution of the Universe

Intrebari fundamentale:

- **De ce au particulele masa ? (boson Higgs, 2012)**

- **Ce sunt masa intunecata, energia intunecata ?**

- **De ce este antimaterial atat de putina ?**

- **Cum era materia imediat dupa Big Bang ?**

Conditiile existente la inceputul Universului pot fi recreate experimental prin ciocnirea particulelor elementare la energii foarte mari, in acceleratoare de particule. In prezent se simuleaza starea de la 10^{-12}s.

Accelerators
LHC

Today

Cosmic Microwave Background

Star and Galaxy Formation

Light nuclei form

Quarks and electrons

Protons and neutrons form

Telescopes

Big Bang

0.000 000 000 1 s

0.000 1 s

100 s

380,000 years

1 billion years

13.8 billion years

"Le CONSEIL EUROPEEN POUR LA RECHERCHE NUCLEAIRE" (CERN)

European Organization for Nuclear Research (CERN) a fost infiintata la 29.09 1954 pentru cercetari in fizica fundamentala a nucleului si a particulelor subnucleare (fizica energiilor inalte).

Are astazi 23 de state membre, 11 membri asociati.
Romania a devenit membru in 2016.

REALIZARI MAJORE

- 2 premii Nobel in fizica fundamentala
  - confirmarea existentei particulei Higgs
  - descoperirea particulelor responsabile de interactia slaba
- 2 premii Nobel pt. noi tehnologii

INOVATII IN TEHNOLOGIA INFORMATIEI

- World Wide Web-ul (martie 1989)
- Gridul de calcul pentru fizica particulelor

ACCELERATOARE DE PARTICULE LA CERN

Proton Synchrotron; ... ; Large Electron-Positron Collider (1989-2000); Large Hadron Collider (protoni, nuclee Pb, Au): ~ 200 PB de date anual

PS – 28 GeV

SPS – 630 GeV

LHC – 13 600 GeV

SC 0.6 GeV

ISR - 31.5 GeV

LEP - 209 GeV

1957   1959   1971   1976   1989   2009

ACCELERATOARELE VIITORULUI LA CERN

New Machines for New Knowledge

Future Circular Collider, e.c.c.m. 100TeV (2045)

FCC

SUISSE

FRANCE

Genève

Annecy

LHC

HL-LHC

High-Luminosity LHC, e.c.c.m. 14 TeV (2029)

(10x mai multe date decat LHC)

EXPERIMENTELE PRINCIPALE DE LA LHC

ALICE - A Large Ion Collider Experiment; ATLAS - A Toroidal LHC ApparatuS; LHCb - Large Hadron Collider beauty

Gridul de calcul al LHC (LCG - *LHC Computing Grid*) = infrastructura distribuita de calcul, coordonata de CERN, care furnizeaza resursele de stocare, procesare si analiza a datelor necesare experimentelor de la LHC.
LCG cuprinde 164 de centre de calcul (site-uri) din 42 de tari, care sunt conectate la o retea virtuala de mare viteza si sunt membre ale colaborarii WLCG (Worldwide LCG, https://wlcg.web.cern.ch/).
Resurse: > 1.200.000 CPU cores; > 2 exabytes storage capacity

Centrele si federatiile de centre grid au fost clasificate dupa contributia lor specifica la WLCG, in Tier-uri (Tier 0 la CERN, Tier 1 si Tier 2). Romania participa cu 6 centre grid grupate in Federatia Tier 2 RO-LCG, la suportul de calcul al experimentelor ALICE, ATLAS si LHCb (https://lcg.ifin.ro/). Centrele respective sunt gazduite, administrate si dezvoltate de IFIN-HH (2 centre), ISS, INCDTIM-Cluj, UAIC-Iasi, UNSTPB.

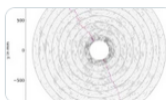Active CPU cores: > 1,200,000
Transfer rate: > 50 GiB/sec

Dezvoltarea de aplicatii pentru HEP@CERN

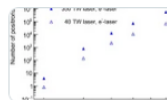Exemple relevant privind programarea de aplicatii pentru HEP: *Computing and Software for Big Science*, Springer, https://link.springer.com/journal/41781/articles

Real-Time Graph Building on FPGAs for Machine Learning Trigger Applications in Particle Physics

Marc Neu, Jürgen Becker ... Kai Unger
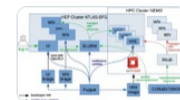
Research | Open access | 21 March 2024 | Article: 8

Deep Generative Models for Fast Photon Shower Simulation in ATLAS

The ATLAS Collaboration

Research | Open access | 05 March 2024 | Article: 7

FunTuple: A New N-tuple Component for Offline Data Processing at the LHCb Experiment

Abhijit Mathad, Martina Ferrillo ... Nicola Serra

Brief Report | Open access | 24 February 2024 | Article: 6

Artificial Intelligence for the Electron Ion Collider (AI4EIC)

C. Allaire, R. Ammendola ... P. Zurita

Review | Open access | 15 February 2024 | Article: 5

PanDA: Production and Distributed Analysis System

Tadashi Maeno, Aleksandr Alekseev ... Xin Zhao

Review | Open access | 23 January 2024 | Article: 4

KinFit: A Kinematic Fitting Package for Hadron Physics Experiments

Waleed Esmail, Jana Rieger ... Karin Schönning

Research | Open access | 07 January 2024 | Article: 3

A Flexible and Efficient Approach to Missing Transverse Momentum Reconstruction

William Balunas, Donatella Cavalli ... Sarah Williams

Research | Open access | 02 January 2024 | Article: 2

Fast Simulation for the Super Charm-Tau Factory Detector

Alexander Barnyakov, Maria Belozyorova ... Daniil Zhadan

Research | Open access | 02 January 2024 | Article: 1

Quantum Algorithms for Charged Particle Track Reconstruction in the LUXE Experiment

Arianna Crippa, Lena Funcke ... Yee Chinn Yap

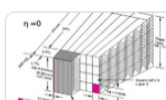Research | Open access | 18 December 2023 | Article: 14

Photon Reconstruction in the Belle II Calorimeter Using Graph Neural Networks

F. Wemmer, I. Haide ... R. Volpe

Research | Open access | 15 December 2023 | Article: 13

GNN for Deep Full Event Interpretation and Hierarchical Reconstruction of Heavy-Hadron Decays in Proton−Proton Collisions

Julián García Pardiñas, Marta Calvi ... Nicola Serra

Research | Open access | 17 November 2023 | Article: 12

Accelerating Machine Learning Inference with GPUs in ProtoDUNE Data Processing

Tejin Cai, Kenneth Herner ... Nhan Tran

Research | Open access | 27 October 2023 | Article: 11

Potential of the Julia Programming Language for High Energy Physics Computing

Jonas Eschle, Tamás Gál ... Vassil Vassilev

Research | Open access | 05 October 2023 | Article: 10

Jet Energy Calibration with Deep Learning as a Kubeflow Pipeline

Daniel Holmberg, Dejan Golubovic & Henning Kirschenmann

Research | Open access | 23 August 2023 | Article: 9

Part of 1 collection:
Learning to Discover at Institut Pascal

Convergent Approaches to AI Explainability for HEP Muonic Particles Pattern Recognition

Leandro Maglianella, Lorenzo Nicoletti ... Simone Scardapane

Research | Open access | 03 August 2023 | Article: 8

Part of 1 collection:
Learning to Discover at Institut Pascal

Lightweight Integration of a Data Cache for Opportunistic Usage of HPC Resources in HEP Workflows

Dirk Sammel, Michael Boehler ... Markus Schumacher

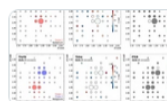Research | Open access | 05 July 2023 | Article: 7

Ntuple Wizard: An Application to Access Large-Scale Open Data from LHCb

Christine A. Aidala, Christopher Burr ... Donijor Tropmann

Research | Open access | 14 June 2023 | Article: 6

Snowmass 2021 Computational Frontier CompF4 Topical Group Report Storage and Processing Resource Access

W. Bhimji, D. Carder ... F. Würthwein

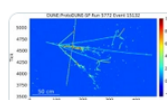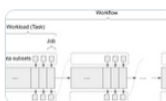Brief Report | Open access | 26 April 2023 | Article: 5

Parametric Optimization on HPC Clusters with Geneva

Jonas Weßner, Rüdiger Berlich ... Matthias F. M. Lutz

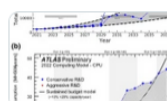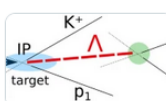Research | Open access | 21 April 2023 | Article: 4

Fast Columnar Physics Analyses of Terabyte-Scale LHC Data on a Cache-Aware Dask Cluster

Niclas Eich, Martin Erdmann ... Yannik Rath

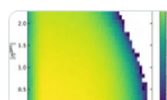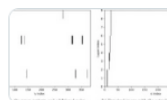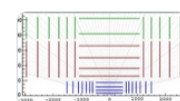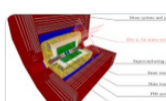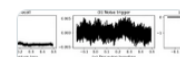Original Article | Open access | 20 March 2023 | Article: 3

The ATLAS EventIndex

Dario Barberis, Igor Alexandrov ... Ruijun Yuan

Research | Open access | 11 March 2023 | Article: 2

The Tracking Machine Learning Challenge: Throughput Phase

Sabrina Amrouche, Laurent Basara ... Jean-Roch Vlimant

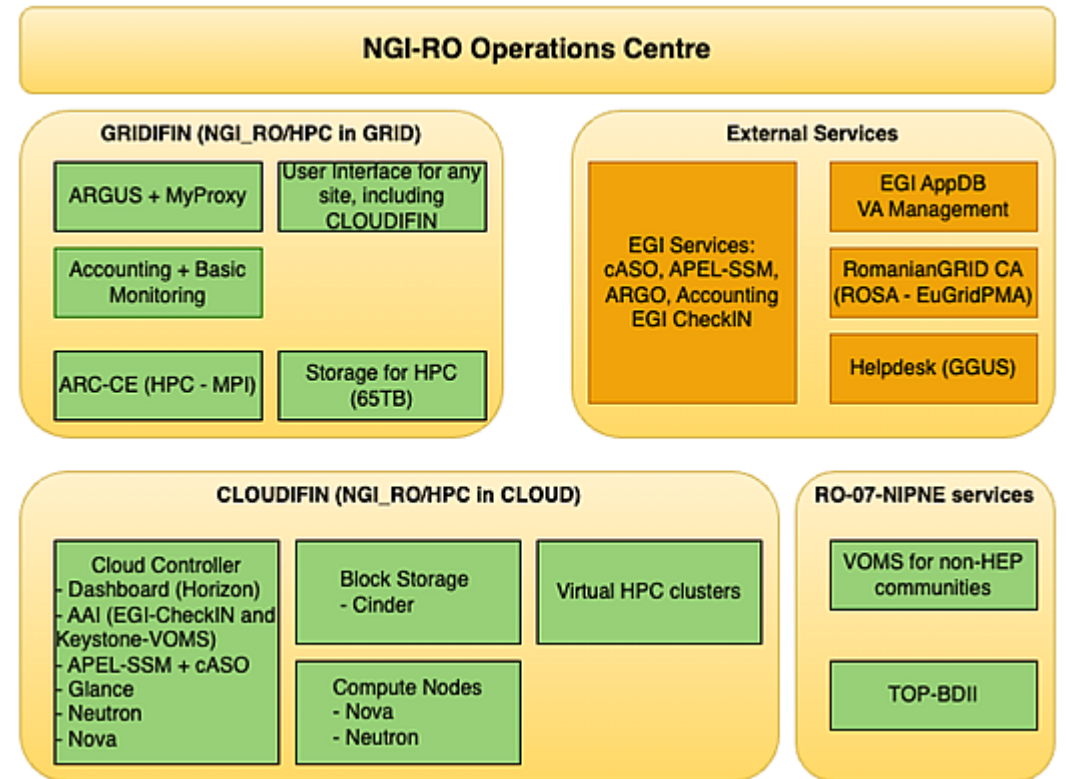Original Article | Open access | 13 February 2023 | Article: 1

Part of 1 collection:
Advanced Tracking Algorithms at the Institut Pascal

Cait: Analysis Toolkit for Cryogenic Particle Detectors in Python

❑ Federatia RO-LCG este coordonata de DFCTI, https://cc.ifin.ro

❑ DFCTI coordoneaza si *Infrastructura Nationala pentru Calcul Stiintific Avansat*, NGI-RO, https://ngi-ro.ifin.ro/

❑ Centrul de Operatiuni NGI-RO

❑ Site-ul grid RO-07-NIPNE, 7.000 cores, 6,5 PB pt. ALICE, ATLAS, LHCb

❑ Site-ul GRIDIFIN, pt. comunitati non-HEP

❑ Site-ul CLOUDIFIN, OpenStack, in EGI FedCloud si EOSC Marketplace

   https://marketplace.eosc-portal.eu/services/eosc.ifin-hh.cloudifin

❑ Servicii HPC in grid si cloud.

INFRASTRUCTURA DFCTI

UPS Emerson Liebert

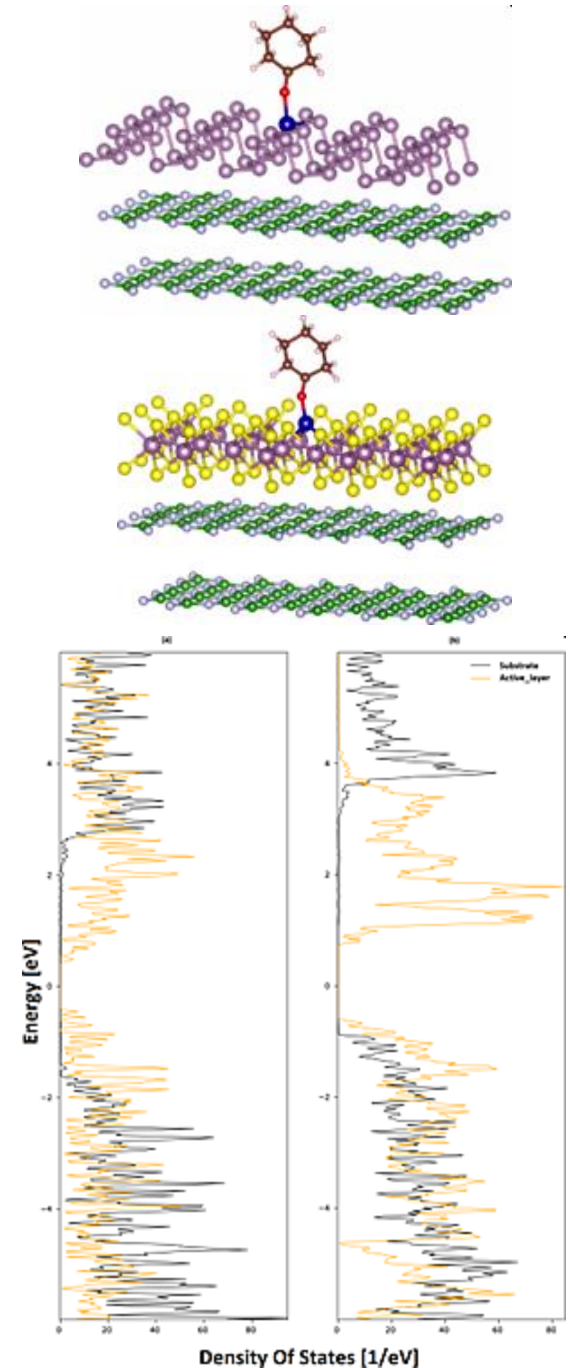Sistem modular InfraStruXure

Climatizare Uniflair Leonardo

Adoptat modelul @CERN

WORLDWIDE LHC COMPUTING GRID (WLCG)

DFCTI - FIZICA COMPUTATIONALA

R&D topics

- ❑ Nuclear and subnuclear physics
- ❑ Physical properties of nanostructures
  - ○ Ab initio calculations for the electronic structure of materials: defect characterization, doping effects, nanostructuring, with applications to solid-state detectors, etc.
  - ○ Simulation of nanoelectronic devices for quantum information processing: quantum sorters, quantum logic gates, nanotransistors.
  - ○ Modeling perovskite solar cells: dynamic J-V characteristics, impedance spectroscopy.
  - ○ Machine learning techniques for condensed matter problems, materials and quantum many-body systems; Inverse design of materials and devices
- ❑ Molecular dynamics of biomolecules
- ❑ Bioinformatics for NGS data analysis
- ❑ High throughput, high performance and cloud computing technology

DFCTI - PRACTICA

DFCTI propune teme de practica legate de dezvoltarea si administrarea infrastructurii de calcul stiintific avansat pentru colaborarea cu organisme europene (CERN, EOSC, EGI - https://www.egi.eu/), de activitatea de cercetare in domeniul fizicii nanostructurilor si nanodispozitivelor electronice.

❑ Metode de invatare automata (machine learning) pentru procesarea datelor stiintifice: retele neuronale pentru predictia proprietatilor fizice (materiale noi, nanostructuri).

❑ Metode de invatare automata pentru procesarea de imagini: metoda pix2pix / TensorFlow.

❑ Programarea si integrarea in dashboard-ul OpenStack a unor noi functionalitati de management al resurselor de calcul Cloud. Cerinte: Python, Django, OpenStack.

❑ Tehnologii HTC (High Throughput Computing): middleware, securitate, planificatoare de job-uri. Programe secventiale, ARC, Slurm, certificate SSL, lansare de joburi pe cluster grid.

❑ Virtualizarea resurselor de calcul: Creare/instalare de masini virtuale, management VM, virtualizare hardware specializat.