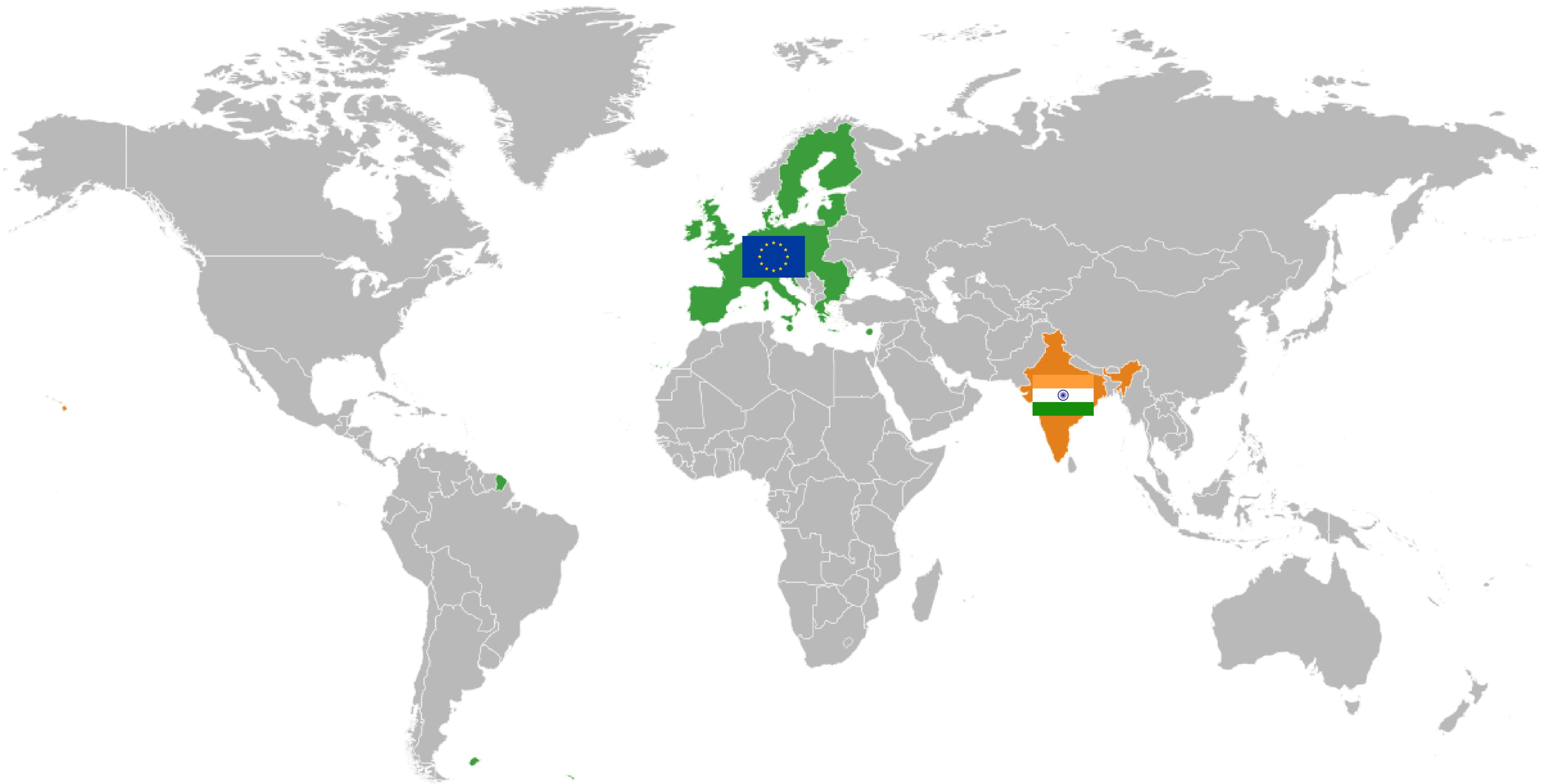
NISER – Wigner Introductory Meeting

Gergely Gábor Barnaföldi, Tamás Kiss
Wigner RCP of the Hungarian Academy of Sciences, Budapest, Hungary

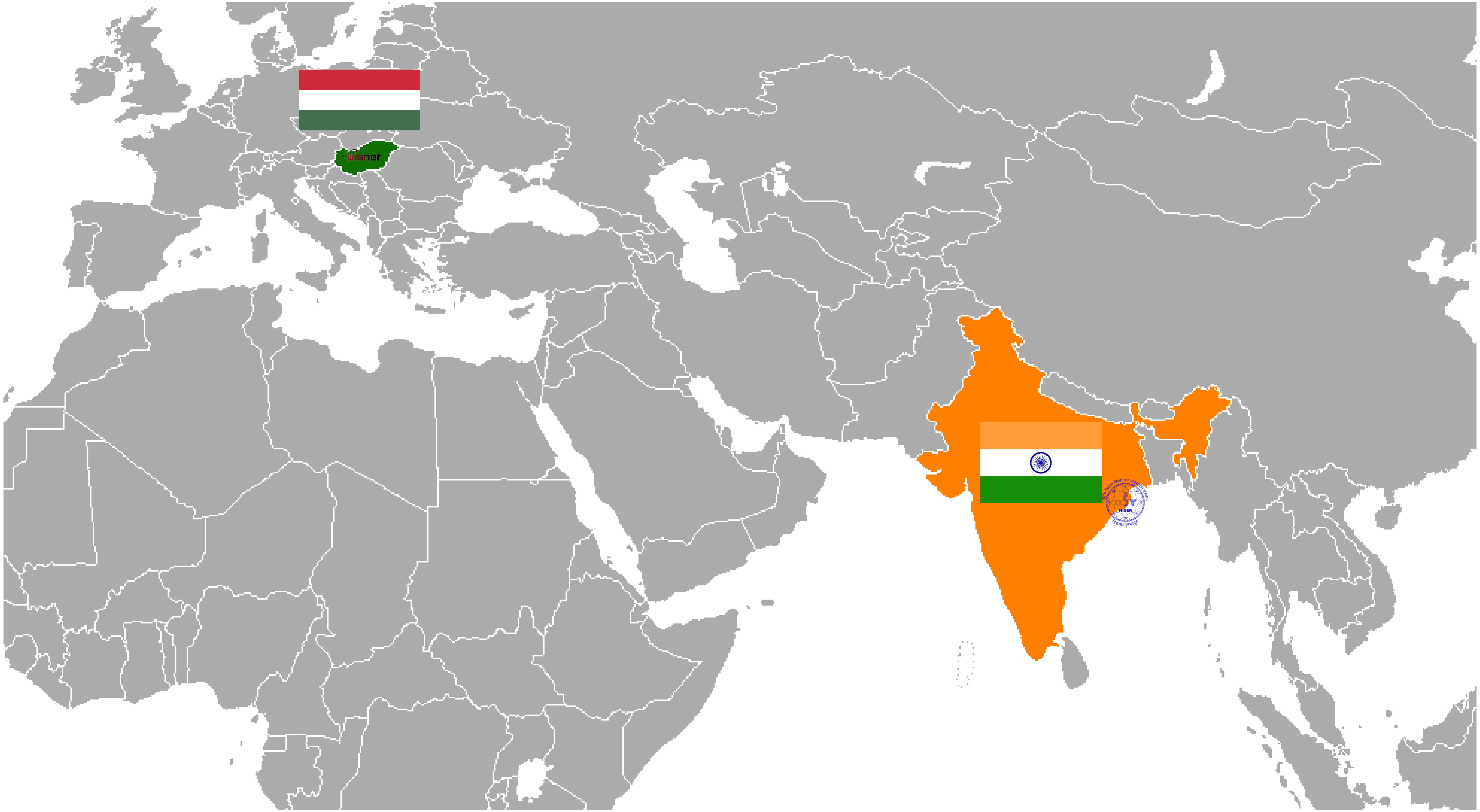
dr. Hilda Farkas
Hungarian Embassy, New Delhi, India

NISER, Bhubaneswar, India, 10th April 2019

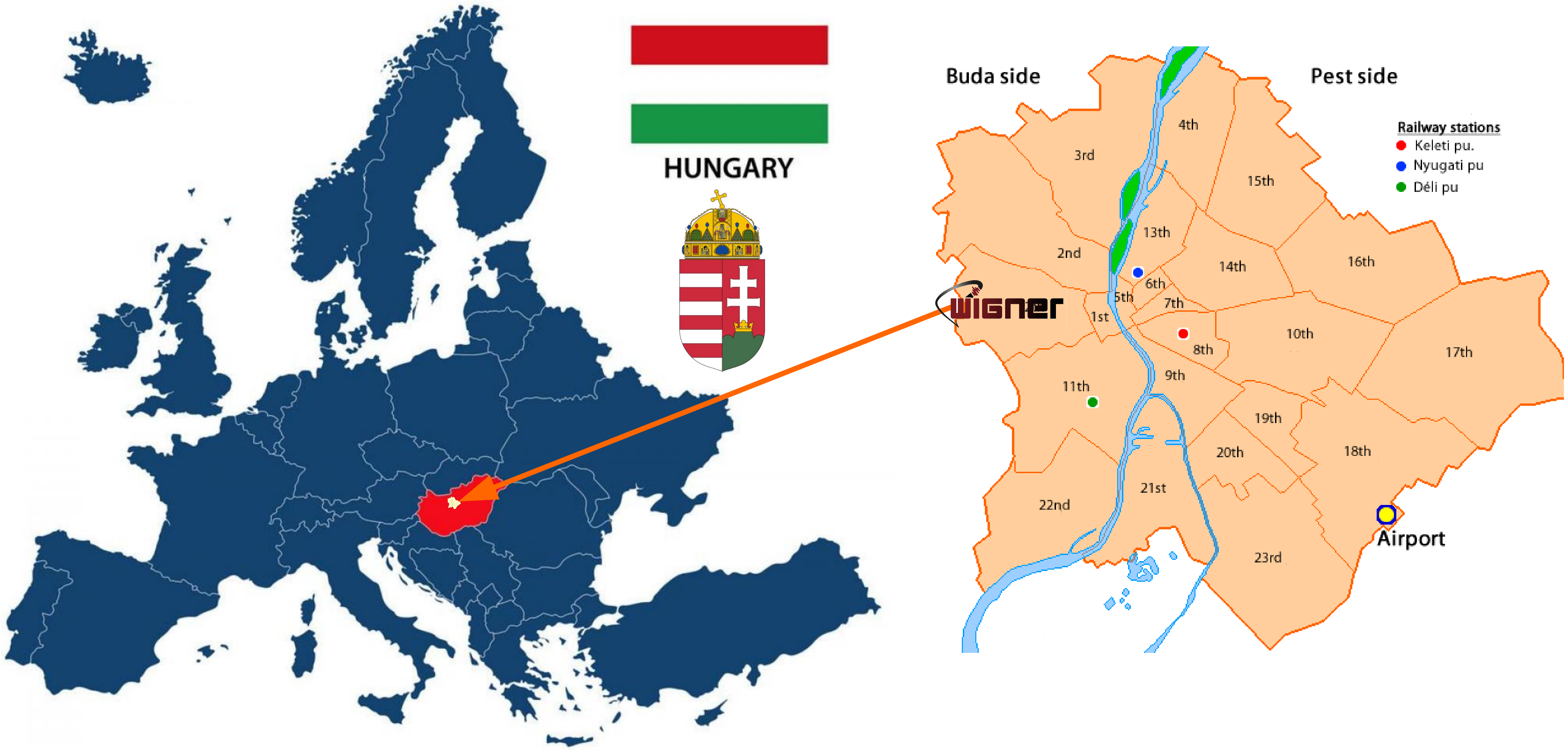
Where are we located?



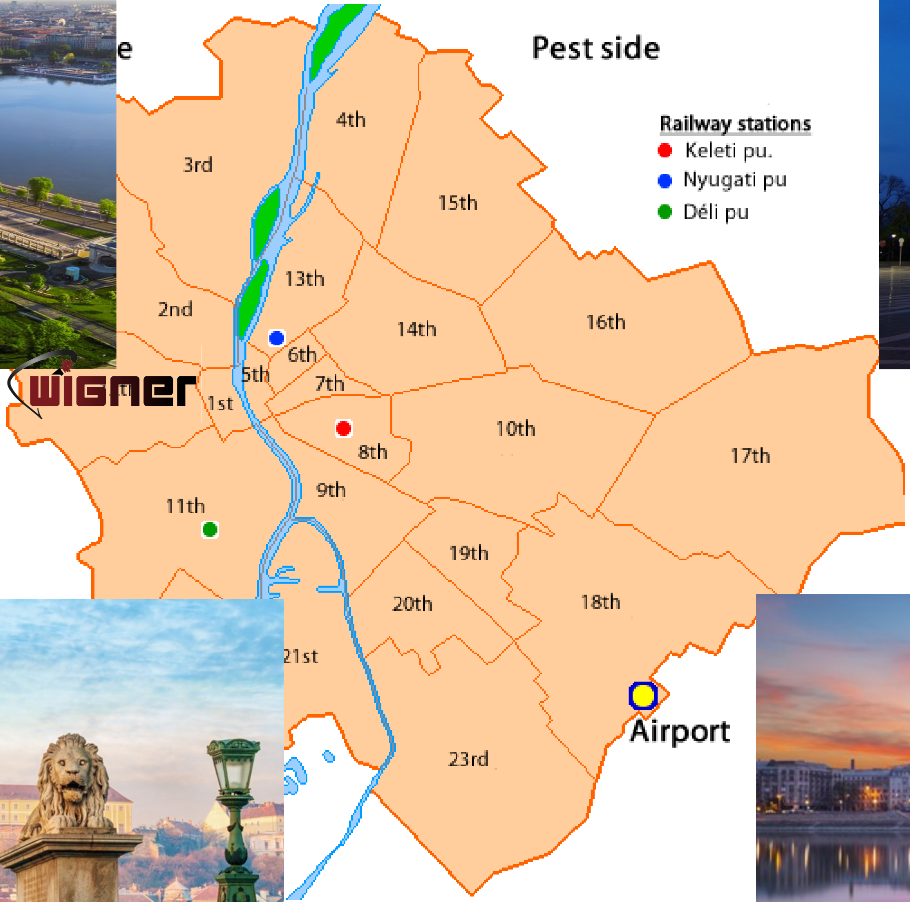
Where are we located?



Where is Budapest, Hungary?



Budapest, the city of beauty



Wigner Research Centre for Physics of the Hungarian Academy of Sciences

Wigner Research Centre for Physics of the Hungarian Academy of Sciences

Institute for Particle and and Nuclear Physics

Particle and nuclear physics
Plasma physics, Brain research
Space science and technology
Information technology

Institute for Solid State Physics and Optics

Solid state physics, crystals
Laserphysics, optics
Neutronphysics, plasmaphysics
Complex system, fluids

History of WIGNER RCP (5y) Successor of KFKI, Budapest (65y)

KFKI
Central Research Institute for Physics

KFKI RMKI
Res. Inst. for Particle and Nuclear Phys.

SZFKI
Res. Inst. for Solid State Physics &Optics

KFKI AEKI
Res. Inst. for Atomic Energy

IKI Res. Inst. for Isotops

MFA Res. Inst. for Technical Physics and Material Sciences

WIGNER Research Centre for Physics

Centre for Energy Research

Eugene Paul Wigner
1902 – 1995

1952 (1972) 1992 2012 (14)

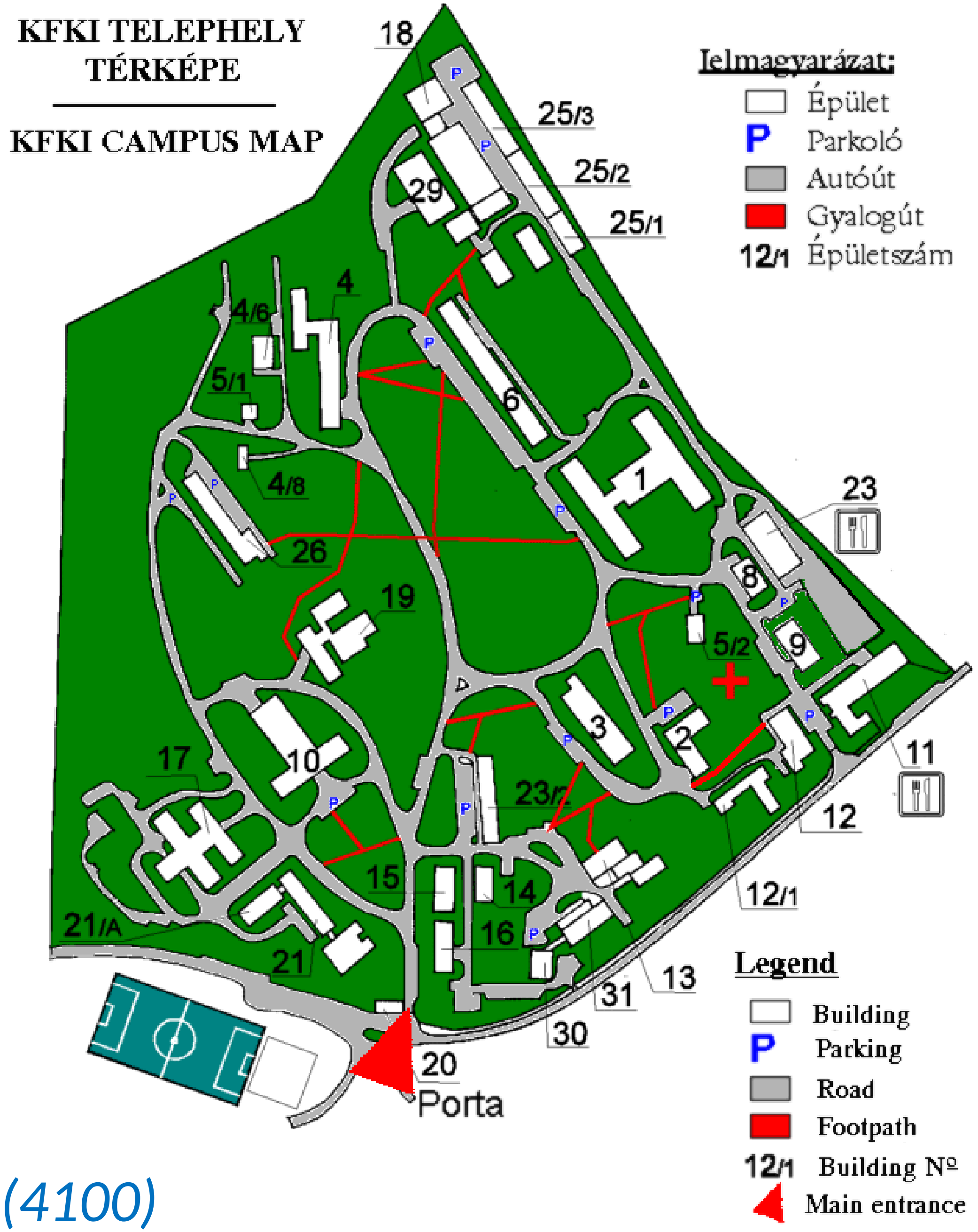
WIGNER Research Centre
for Physics, HAS

By 2019:

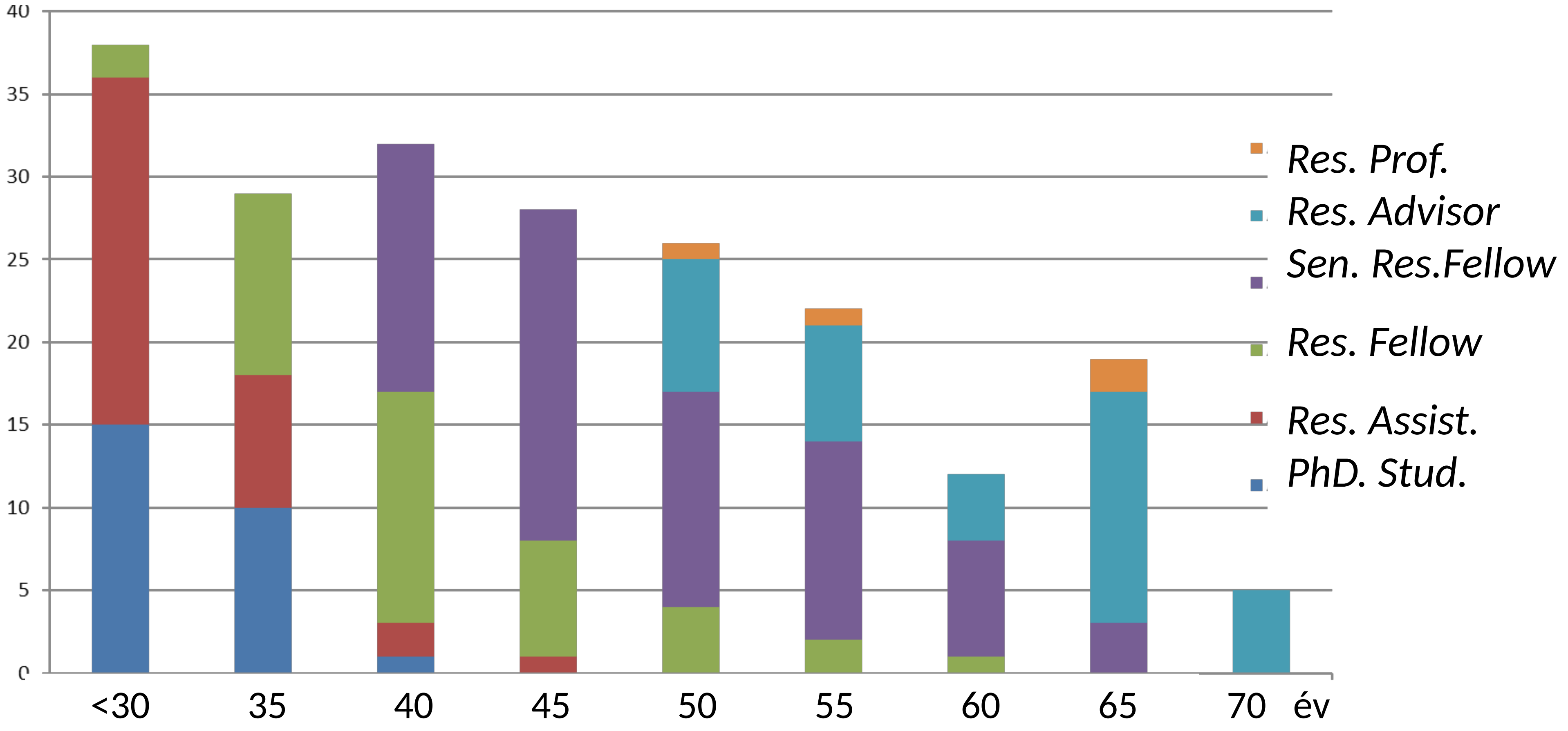
160 researcher[PhD] (7 FIKU)
51 young res. (19 FIKU)
157 technical +
administ. staff

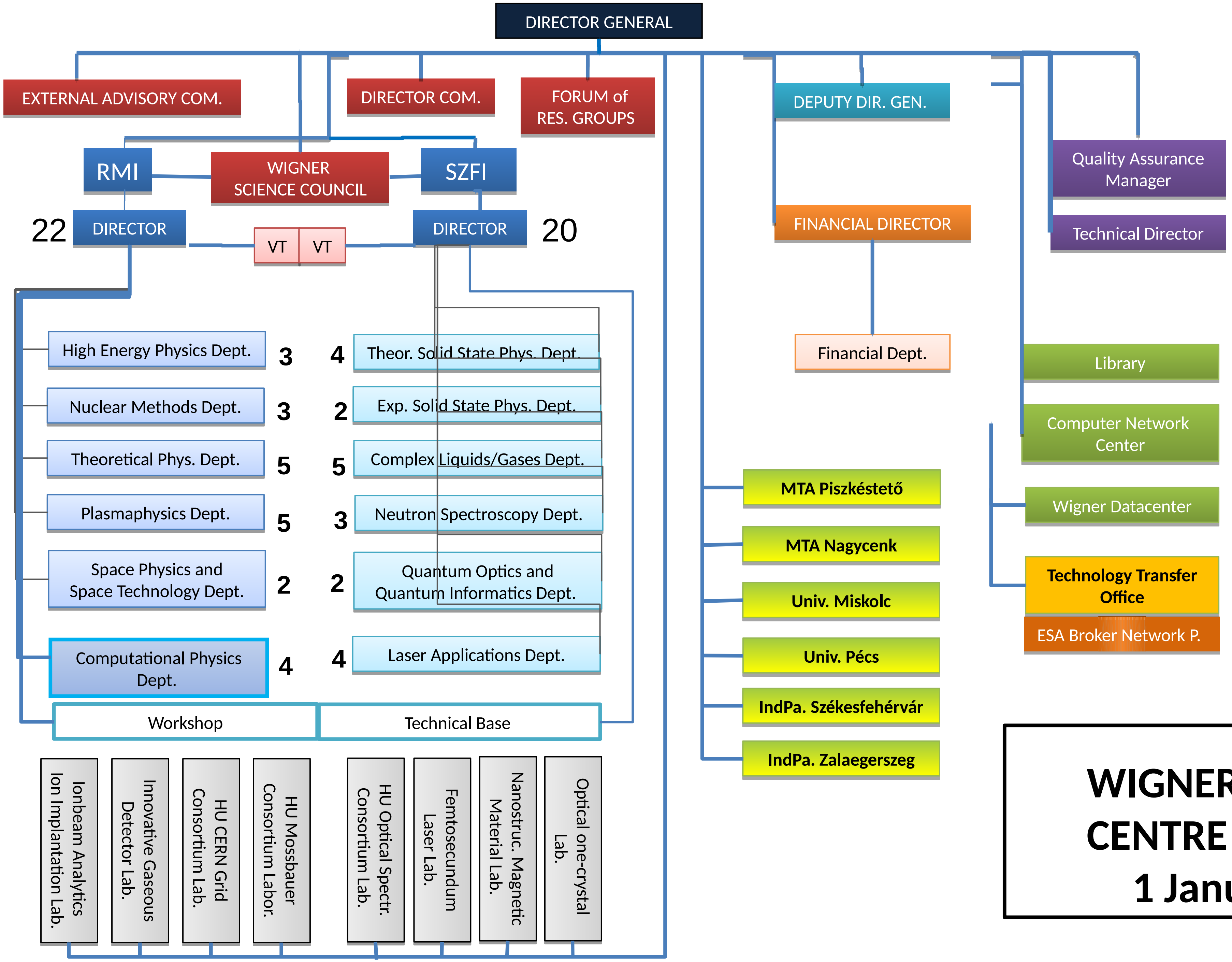
368 employees + 21 Prof. Emer.

2019 Budget: 16.5M€ 9 % of HAS (4100)



Researchers age distribution – 1 October 2017





WIGNER RESEARCH CENTRE for PHYSICS
1 January 2019

The missions of the MTA Wigner RCP

Institutes of Basic Research
Research Groups
Table top exp.

National Laboratory
Long term commitments
International large scale RIs

Applications in industry
Innovation center
Technology transfer

Education
Training center
Knowledge transfer

Annual reports: the summary of our yearly activities
https://wigner.mta.hu/en/yearbook

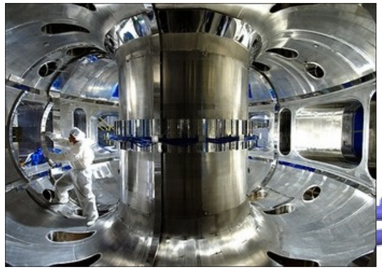
Focus topics at Wigner RCP
during period of 2014-2020
connecting to strategy of EU HORIZON2020
and Hungarian Smart Specialization (S3)

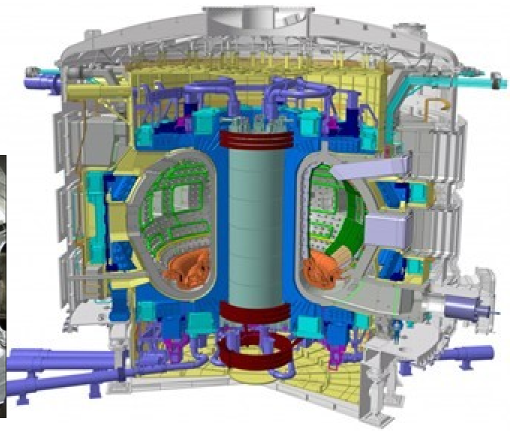
- *Special materials*
- *Innovative detectors*
- *Plasmas and lasers*
- *Quantum technology*
- *Information technology*
- *Physics for Health*

Flagship projects on Large Scale Research Infrastructures:

1. High Energy Physics

2. Fusion Energy Research (EURATOM, F4E) [Plasmadiagnostics]





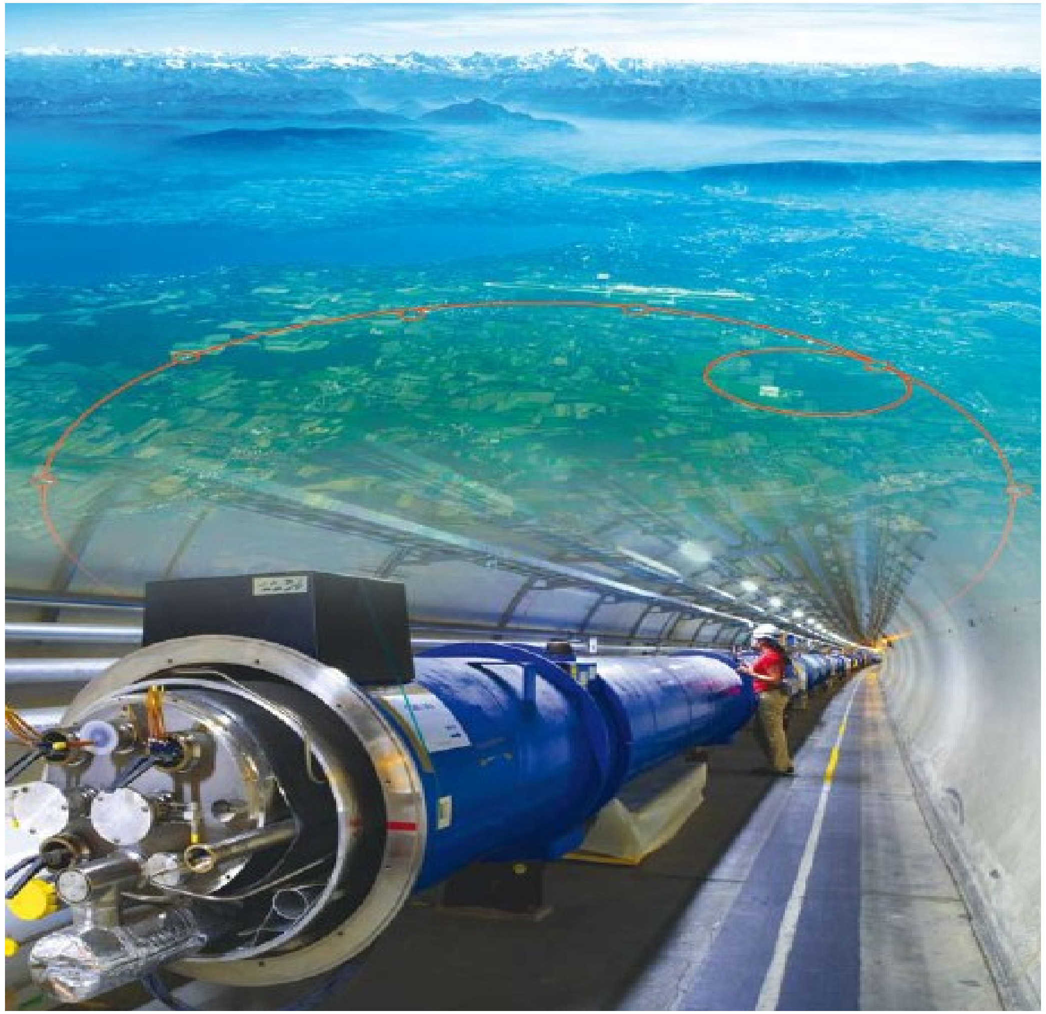
MAST, Culham   EAST, Hefei   KSTAR, South Korea   ITER, Chadarache

Machine: LHC (Large Hadron Collider)

14 TeV proton-proton collider built in the LEP tunnel

Lead-Lead (Lead-proton) collisions

1983 : First studies for the LHC project
1988 : First magnet model (feasibility)
1994 : Approval of the LHC by the CERN Council
1996-1999 : Series production industrialisation
1998 : Declaration of Public Utility & Start of civil engineering
1998-2000: Placement of the main production contracts
2004 : Start of the LHC installation
2005-2007: Magnets Installation in the tunnel
2006-2008: Hardware commissioning
2008-2009: Beam commissioning and repair
2009-2035: Physics exploitation



Tool: "High Energy LHC"

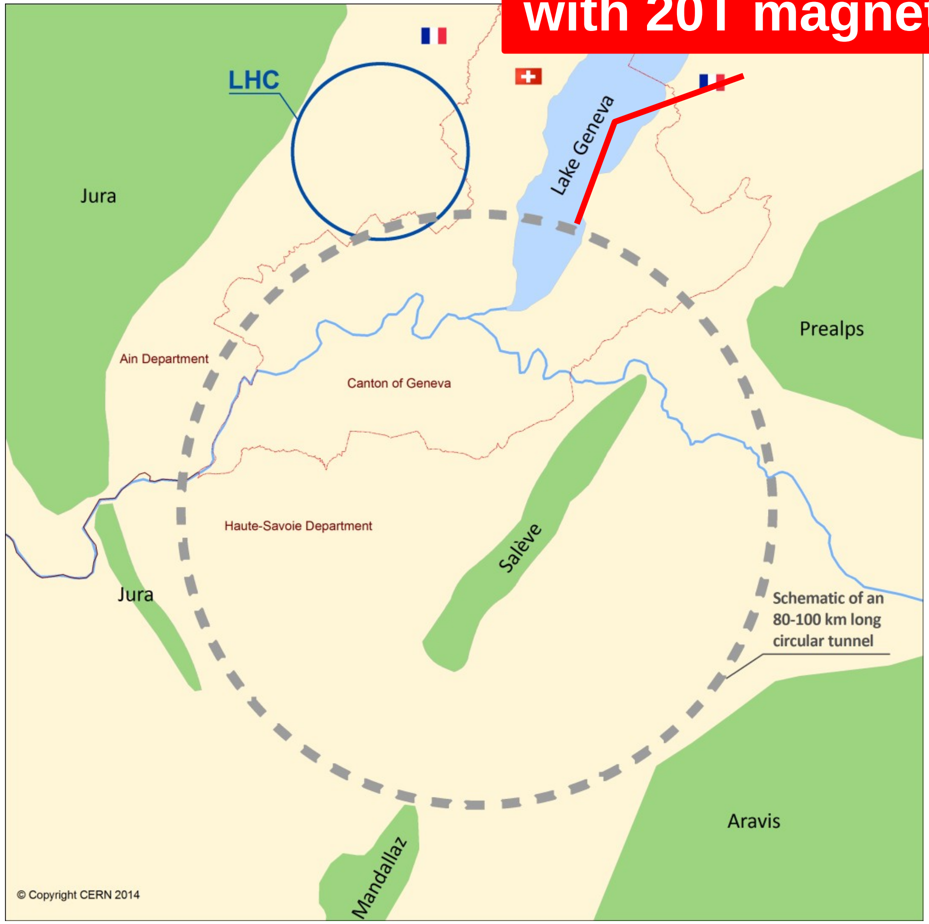
First studies on a new 80 km tunnel in the Geneva area

42 TeV with 8.3T using present LHC dipoles

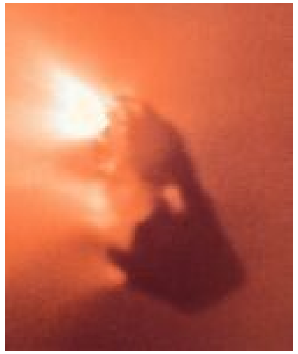
80 TeV with 16 T based on Nb_3Sn dipoles

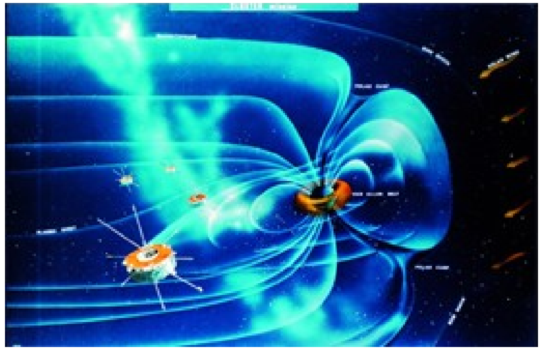
100 TeV with 20 T based on HTS dipoles

HE-LHC :33 TeV with 20T magnets

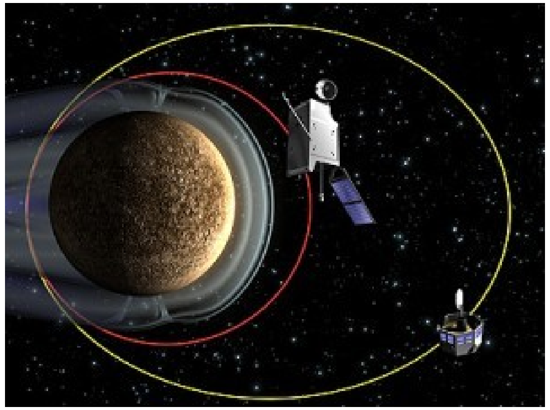


3. Space Science & Technology

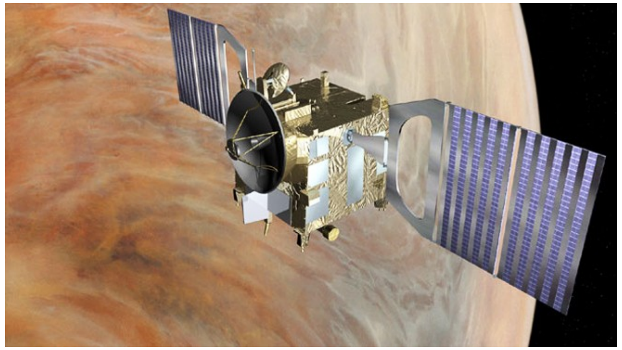




Comet Halley: Vega 1/2 (1986) **Saturn&Titan: Cassini (2004-17)** **Earth: CLUSTER Mission (2001-14)**

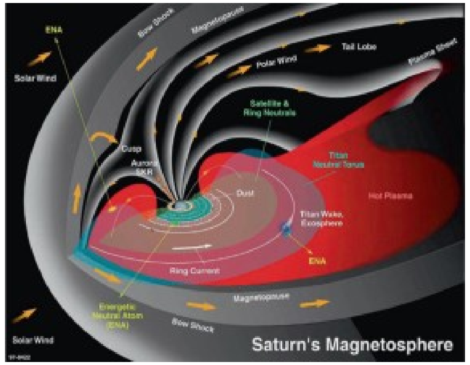


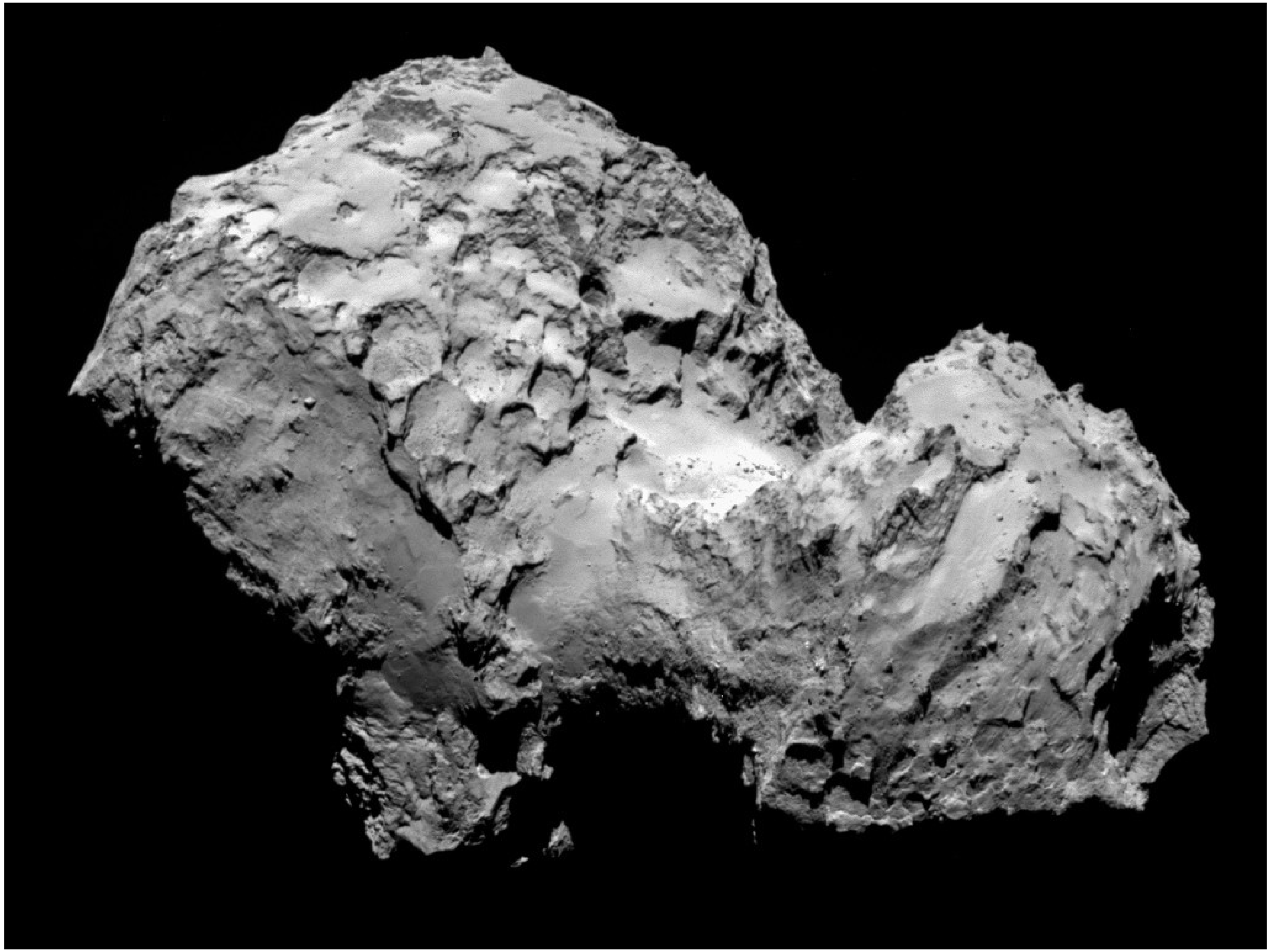
Rosetta – Philae probe (2004-17) **Mercury: BepiColombo (2014)** **ISS: Plasma Wave Complex (2011)**



Venus Express (2006)
Saturn’s Magnetosphere

CASSINI ⊔ SATURN
ESA BNP, BIC; NASA





2014: The Rosetta probe approached the Comet 67P/Churyumov-Gerasimenko.
The PHILEA-unit landed on the Comet and first data were transmitted.
HU Group (Wigner RCP, ER, BME) prepared the DAQ of PHILEA.

ESA Broker Network Point
at Wigner RCP Technology Transfer Office (27 January 2017)

http://mta.hu/english/office-in-wigner-center-supports-hungarian-use-of-space-technology-107379

Recent activity:
opening
ESA BIC
(Business
Innovation
Centre)

+ collaboration
with NASA
(27 March)

4. The nature of gravitation
Gravitation Waves – VIRGO Collaboration (2005-)

EGO VIRGO: Cascina (Pisa, Italy)

LIGO: Hanford (USA) Livingston (USA)

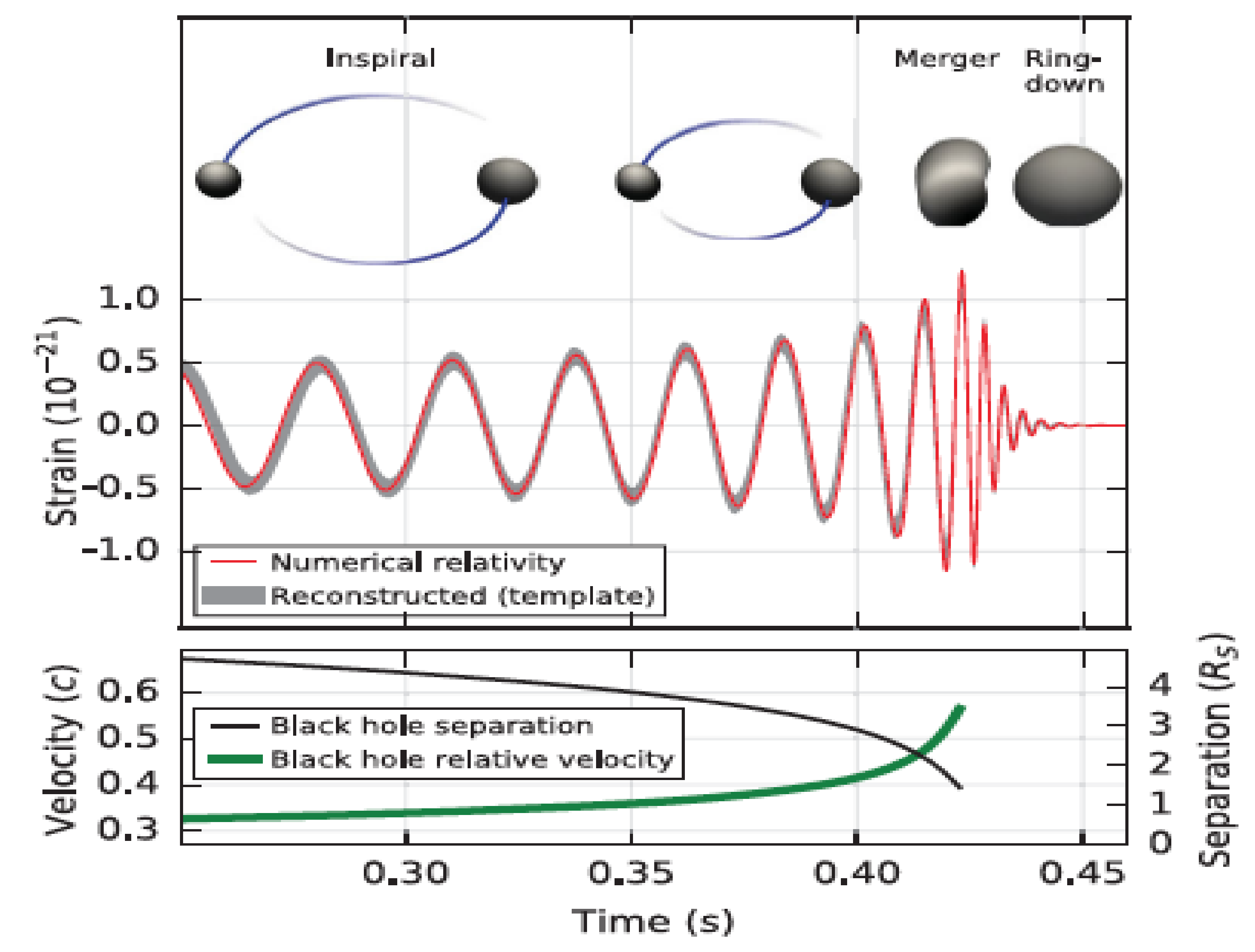
LIGO/VIRGO Collaboration (2007):
integrated common data analysis
GW-150914: 50 Million CPU-hour
ELTE-ATOMKI-Szeged and WIGNER RCP partic.

Contribution from Wigner RCP:

- Theoretical studies
- Data analysis
- IT: VIRGO Cluster in the Wigner Cloud
- MATRA Gravitation and Seizmology Laboratory, Gyöngyösoroszi (Test period started: 25 Febr. 2016)

GW150914: First direct detection of gravitational wave

Phys. Rev. Lett. **116**, 061102 (2016)



Blackholes with 29 and 36 solar masses merged ▭
during 0,05 sec energy of
3 solar masses has been released as GraviW =
Atomic power plan at Paks, energy production of 10^{31} y !

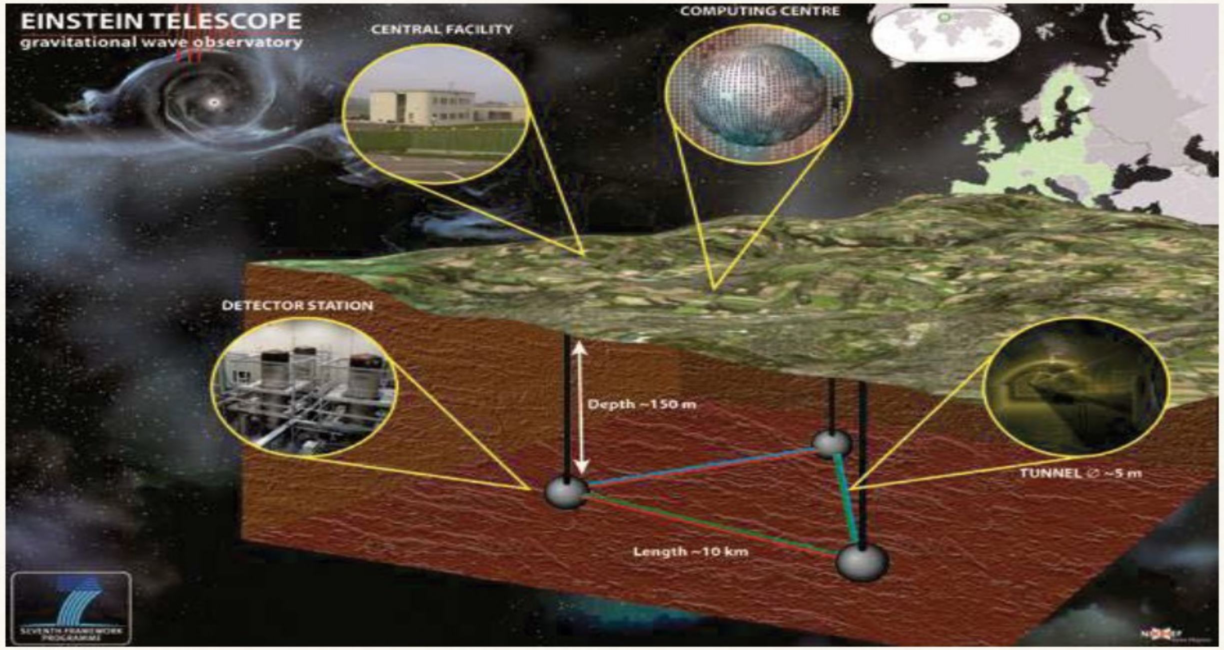
The interferometer of Advanced LIGO detected
length-modification
in the order 1/1000
of the size of the proton !

1-2 attometer !!!

Future plans - 3th generation

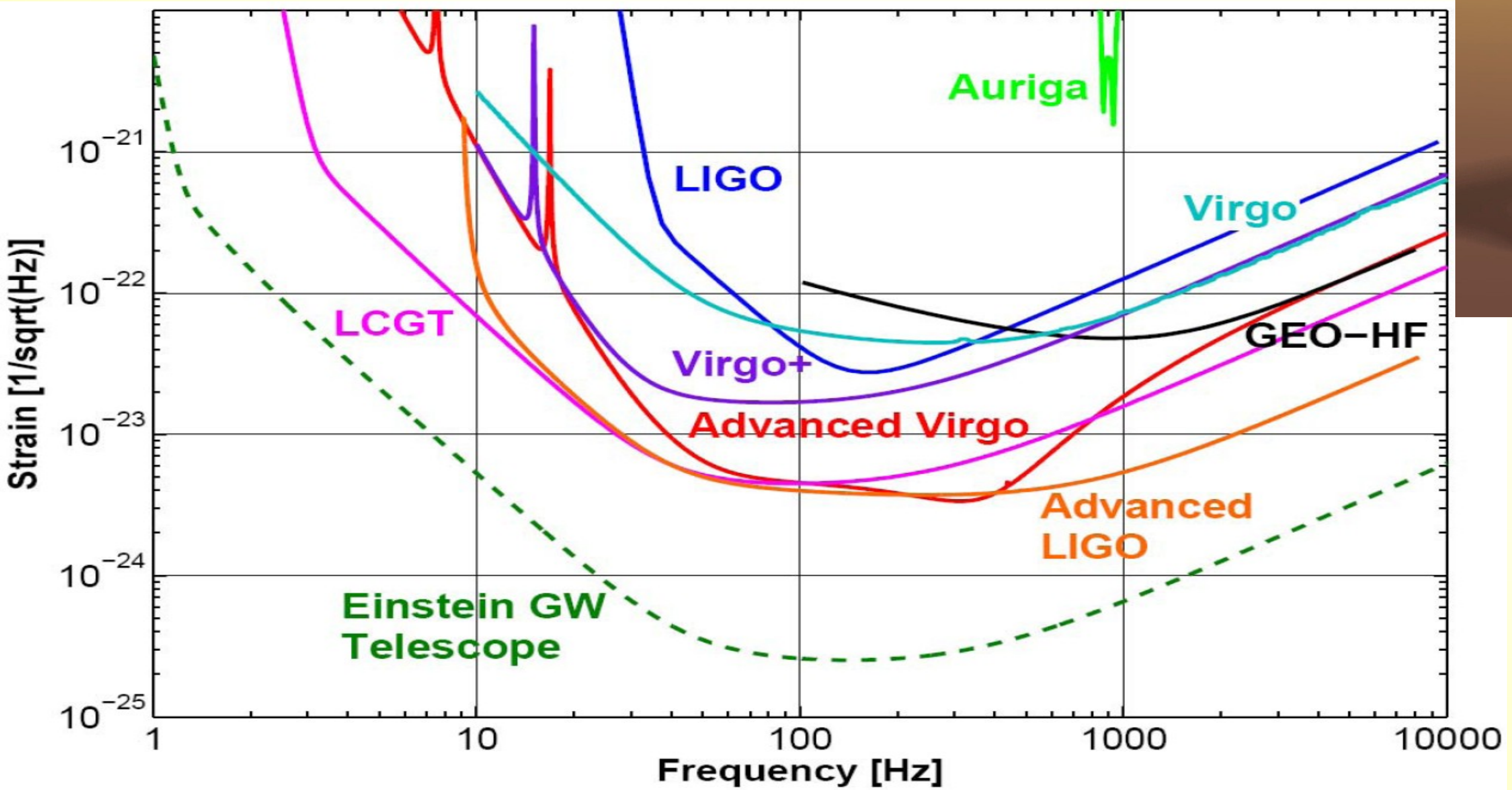
- Continuous improvements of the 2nd generation GW-detectors
- International collaboration for development a 3th generation GW-detector
  Gravitational **W**ave **I**nternational **C**ommittee >>> Einstein Telescope

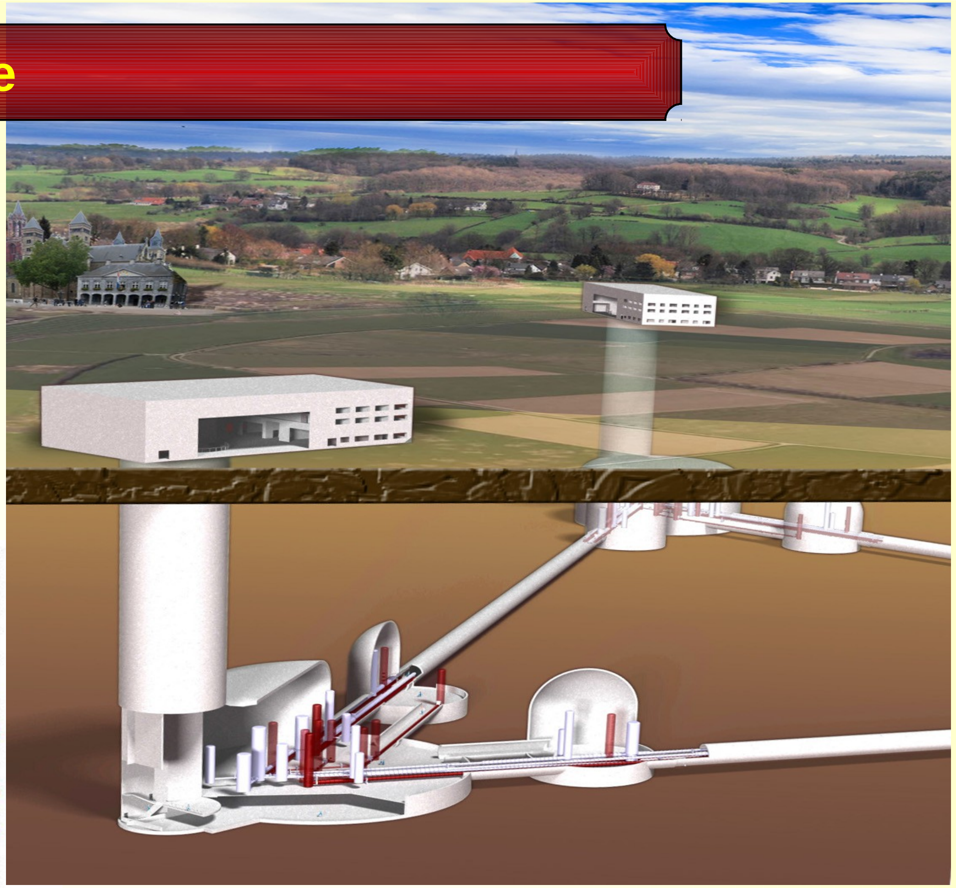
Observing run	Epoch	Duration (months)	aLIGO sensitivity	AdVirgo sensitivity
O1	2015–2016	4	Early	—
O2	2016–2017	6	Mid	Early
O3	2017–2018	9	Late	Mid
O4	2019	12	Design	Late
O5	2020+	–	Design	Design



The future: Einstein Telescope

Testing general relativity with higher precision:
- new polarization states ?
- massive graviton?
- the accelerating expansion of the Universe (testing dark energy)?

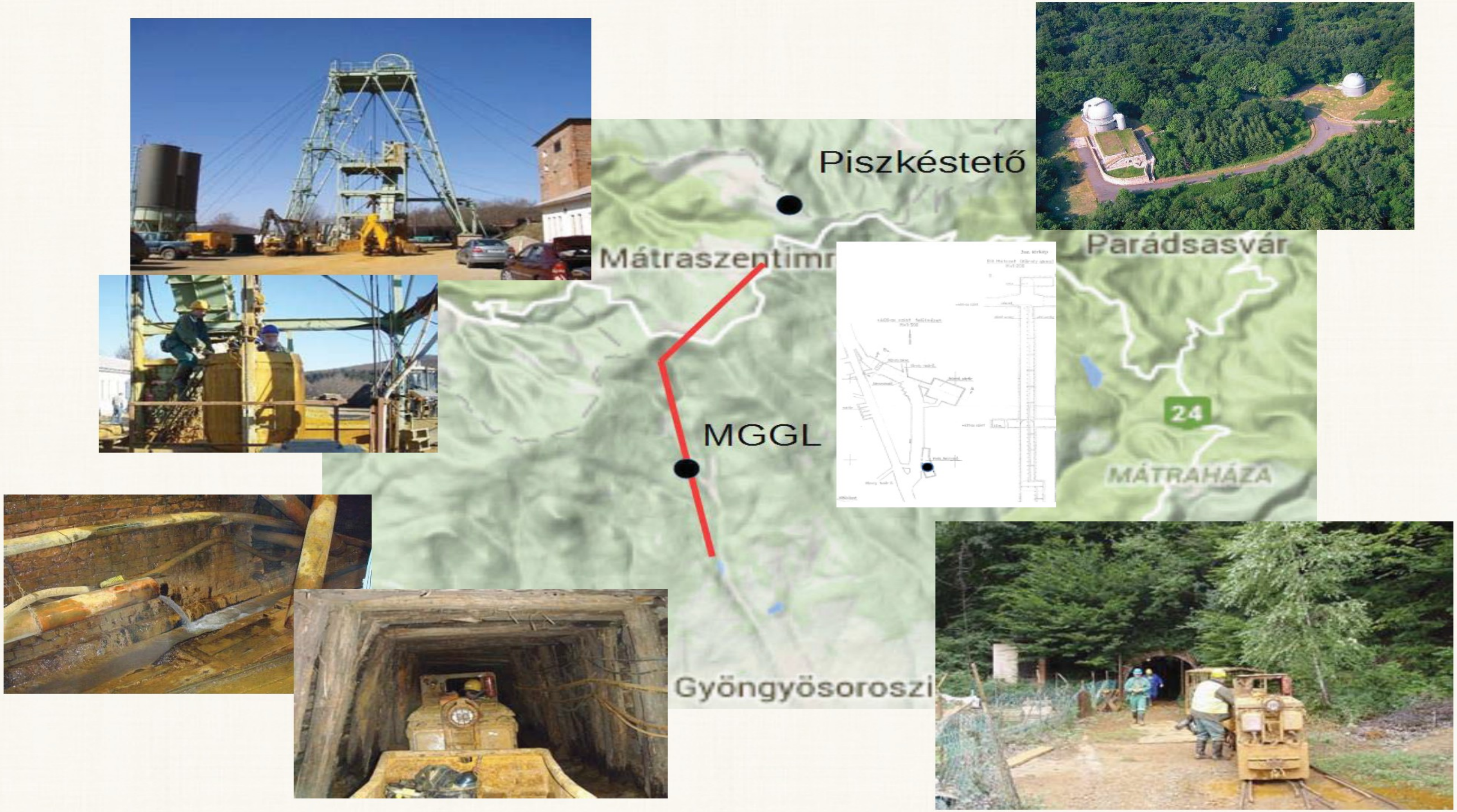




Expected sources of GWs:

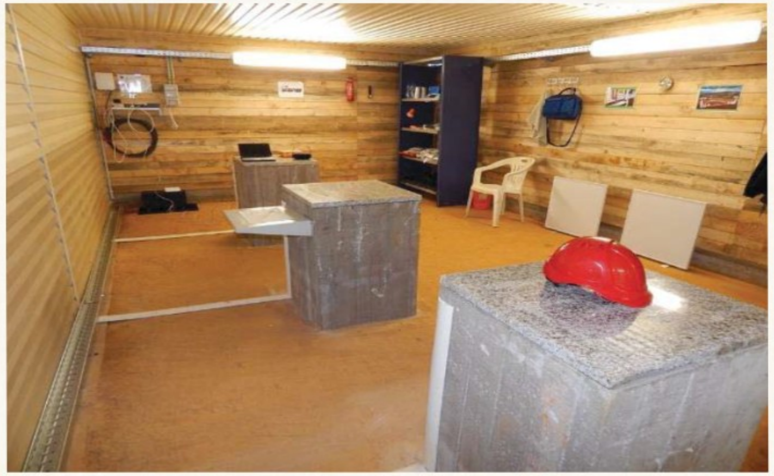
- Merging of black holes with large masses
- Neutronstar – merging
- Assymmetric supernova-explosions
- gamma-bursts

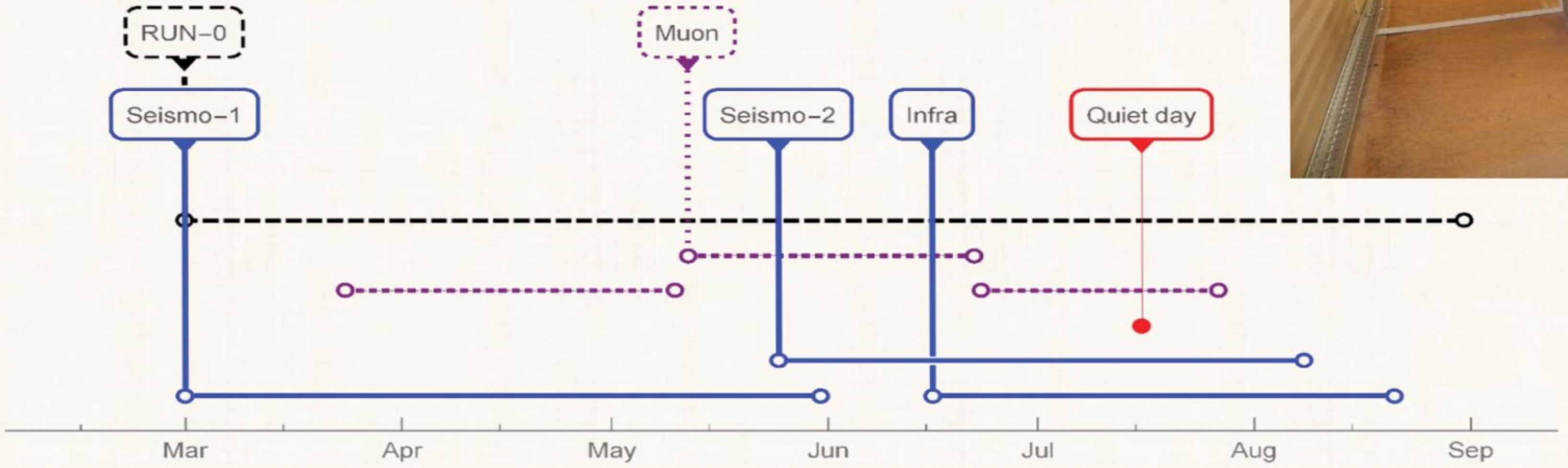
Ore mine in Gyöngyösoroszi - Mátra Mountine



Matra Gravitation and Geophysics Laboratory

- MGGL construction finished by February 2016
  - 1.3 km from entry, 88 m underground
  - 3 location
  - optical cabel for fast internet
  - data collection from March 2016
  - **Class. Quantum Grav. 34, 11401 (2017)**



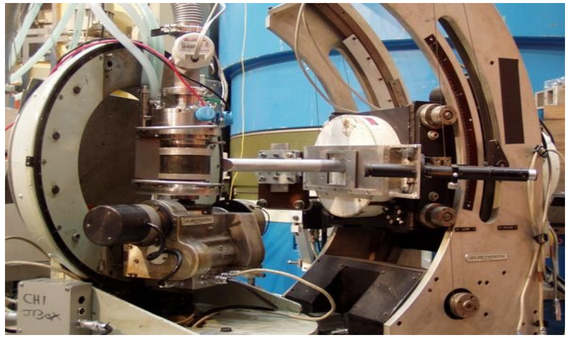


5. Budapest Neutron Center (BNC) [Experience in infrastructure management]

BUDAPEST Reactor (10 MW)

GINA polarized neutron reflectometer

Cold Neutron Laboratory



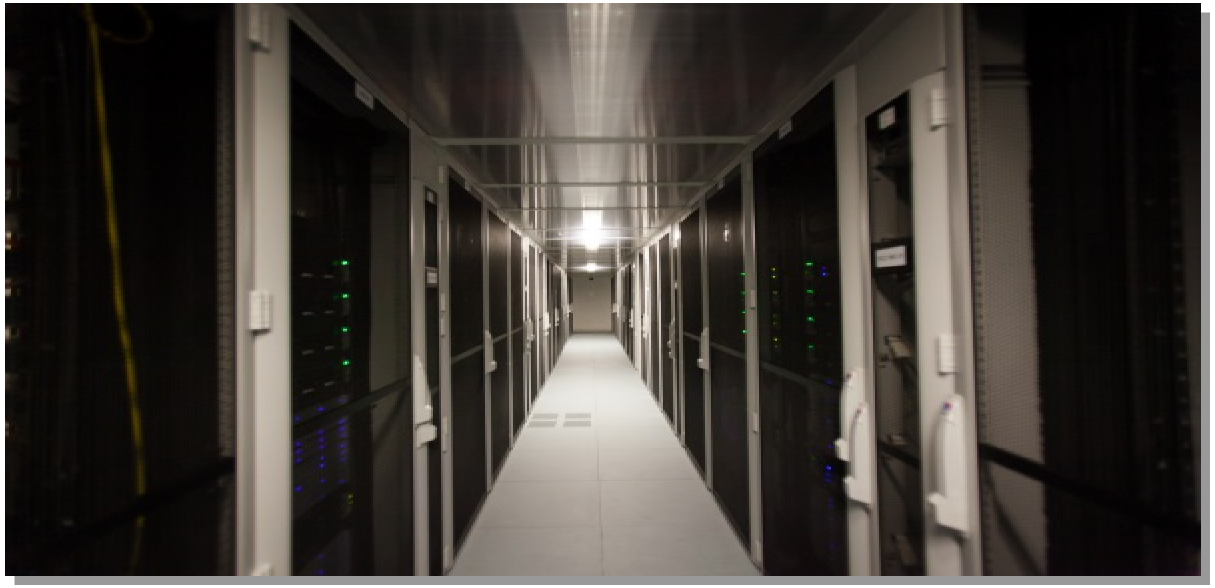
MTEST diffractometer

EUROPEAN
SPALLATION
SOURCE

WIGNER Datacenter -- MTA WIGNER RCP

From 1 January 2013: hosting CERN TIER-0

1300 km 2 x 100 Gbit/s (3 x 100 Gbit/s)



High reliability data transfer, data handling, data mining

Mission: Knowledge center, know-how transfer

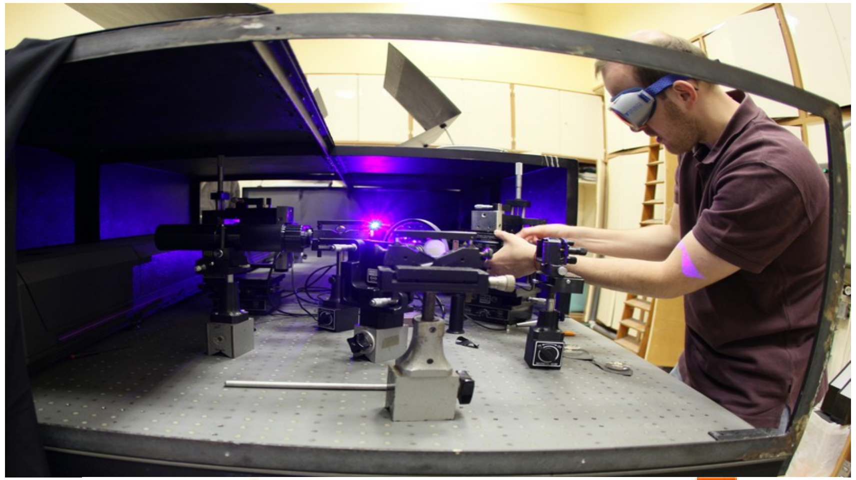
Big Data Day, GPU - Multicore Workshop, (2011-)

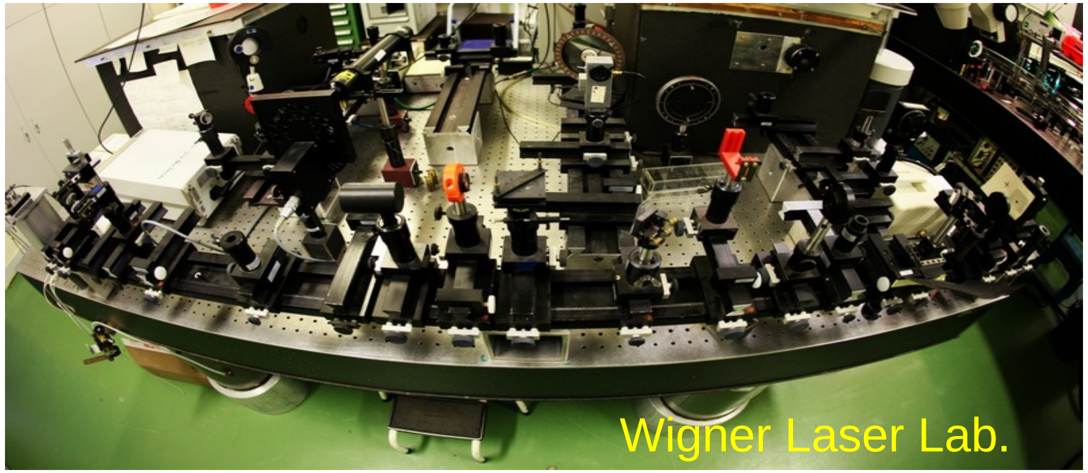
HEPTECH AIME ICT (2015, 2018)

Wigner Could (1000+ core), MTA Cloud (1000+ core)

+ GPUminisuper comp. + 2 PB HD

5. Laser Physics and Quantum Optics [femtosecond lasers → attosecond]

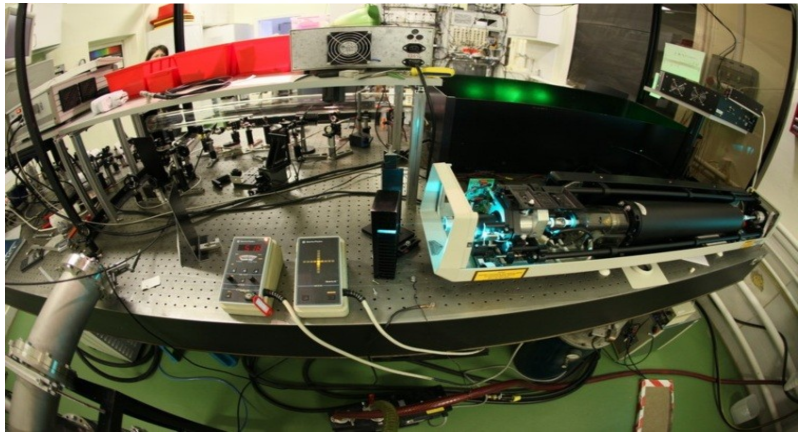


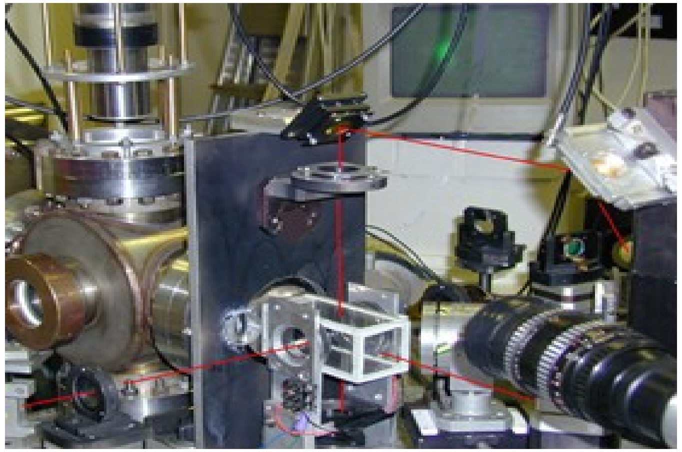


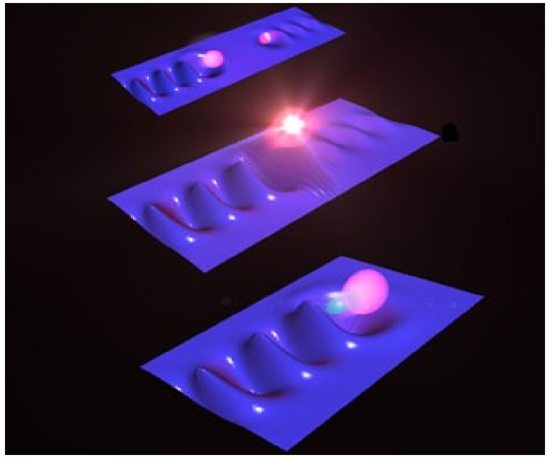
eli
extreme light infrastructure

Szeged
2017/05/23
Inauguration
Prag, Bucharest

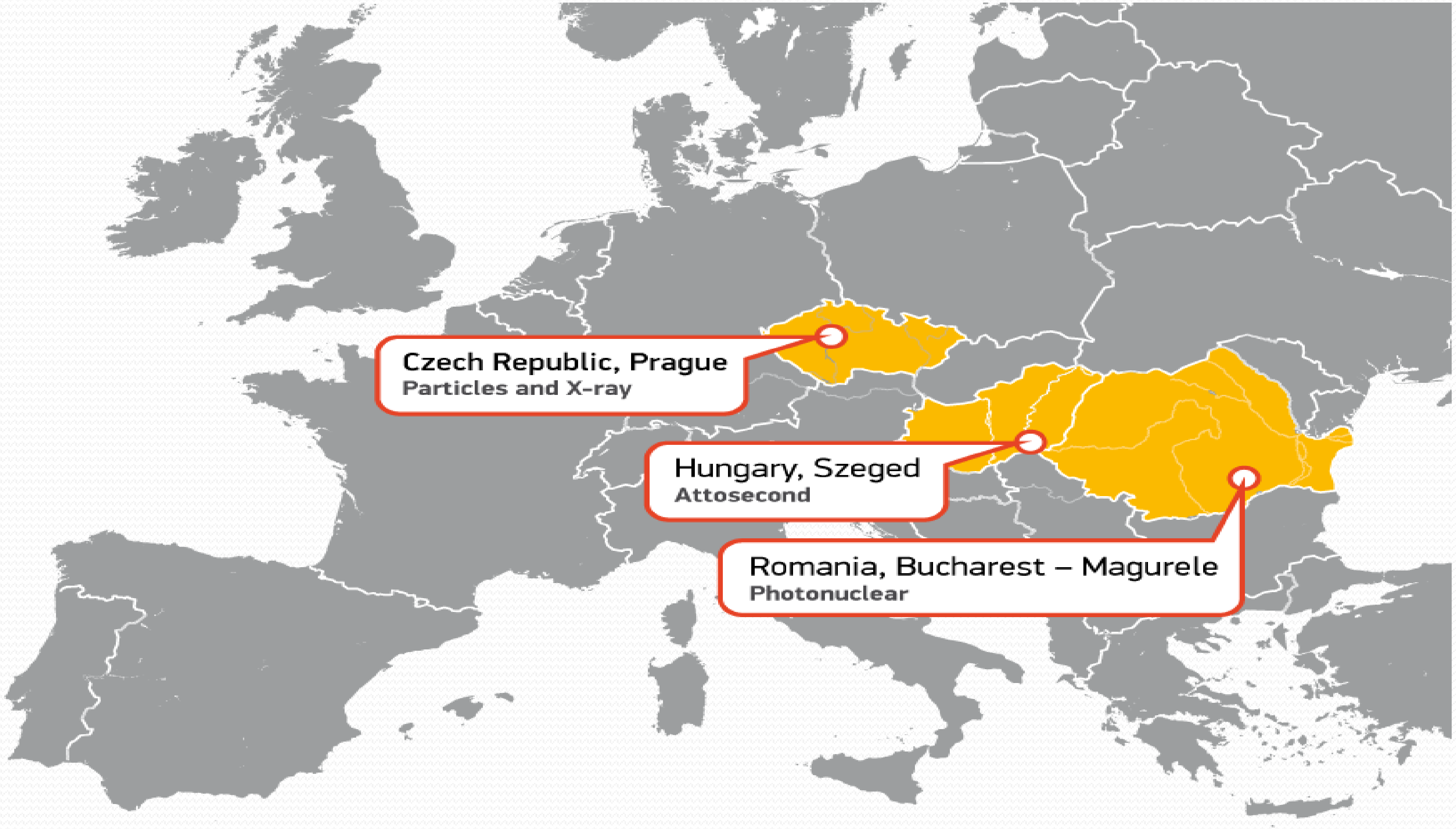
Plan: CERN - PDPWA
Proton Driven
Plasma Wave
Accelerator research







ELI: Extreme Light Infrastructure-
Three pillars, three locations



ELI: Extreme Light Infrastructure-
Tasks at each facility

ELI-Beamlines

In Dolni Brezhany, near Prague, Czech Republic, the **ELI-Beamlines** facility will mainly focus on the development of short-pulse secondary sources of radiation and particles, and on their multidisciplinary applications in molecular, biomedical and material sciences, **physics of dense plasmas and particle acceleration**, warm dense matter, laboratory astrophysics.

ELI-Nuclear Physics Facility

In Magurele, Romania, the **ELI Nuclear Physics** (ELI-NP) facility will focus on laser-based nuclear physics.

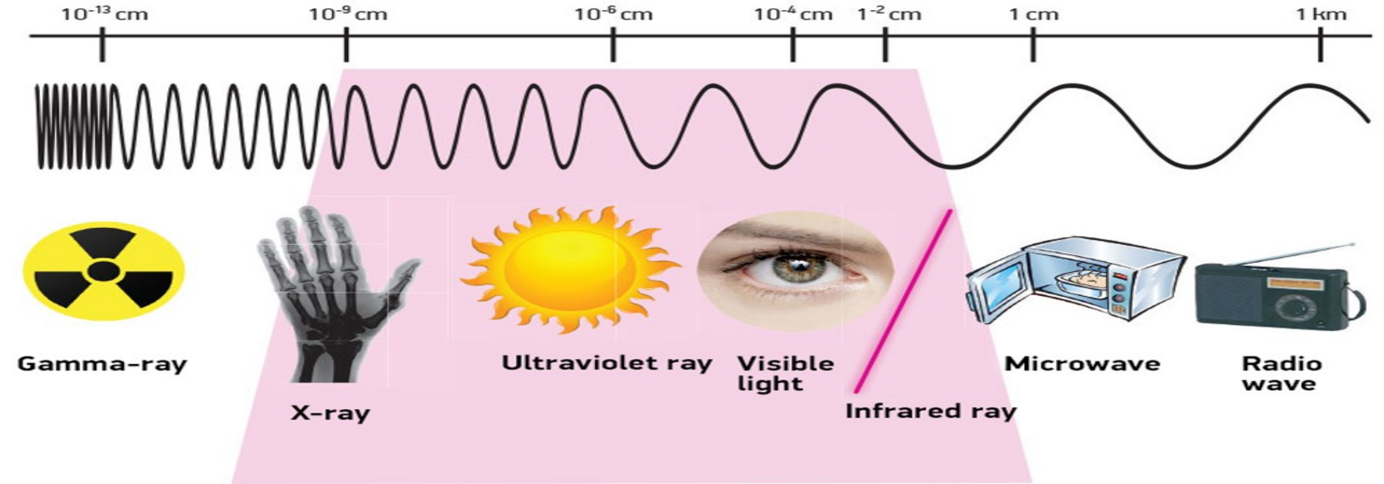
ELI -ALPS Hungary

Atto-second Light Pulse Source: Generation of 200 PW peak intensity pulses of sub-femtosecond and atto-second durations in extreme -ultraviolet and X-ray regions.

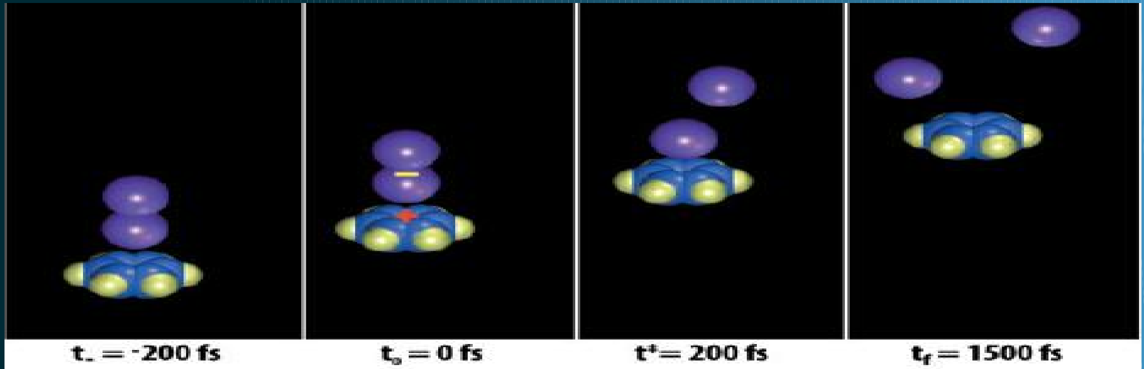
ELI-ALPS is expected to be partially available in 2017, while it will become fully operational for user-based research in 2018-19.

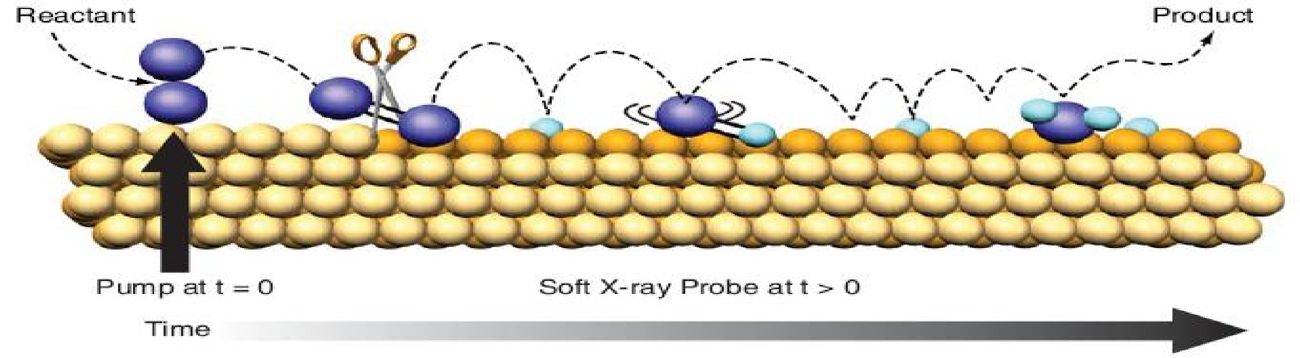
ELI-ALPS today

The primary mission and applications of the ELI-ALPS



A wide range of ultrashort light sources with unique parameters





Attosecond tools for chemistry, biology and nanoscience

Main research and application areas of ELI-ALPS

Valence electron science

Based on the extreme ultraviolet and the X-ray sources provided by ELI-ALPS, new research areas will open in the fields of atomic and molecular dynamics, studying valence electrons responsible for the behavior of chemical reactions.

Core electron science

Using the high photon-energy, high brightness extreme-ultraviolet and X-ray source core electrons will become accessible. The unique combination of light sources offered by ELI-ALPS, will open a unique opportunity to follow the dynamics of inner shell electrons on the atto-second time scale.

4D imaging

Atoms, molecules, crystals and nanostructures all consist of nuclei and electrons. The 3D arrays of these particles define the structure and static/equilibrium characteristics of the material. If the system is excited, the nature and time evolution of the response may be recorded in space and time (4D).

The secondary light sources produced at the ELI-ALPS infrastructure will nourish the development of 4D imaging and will allow the visualization of electron motion with attosecond temporal and atomic spatial resolution.

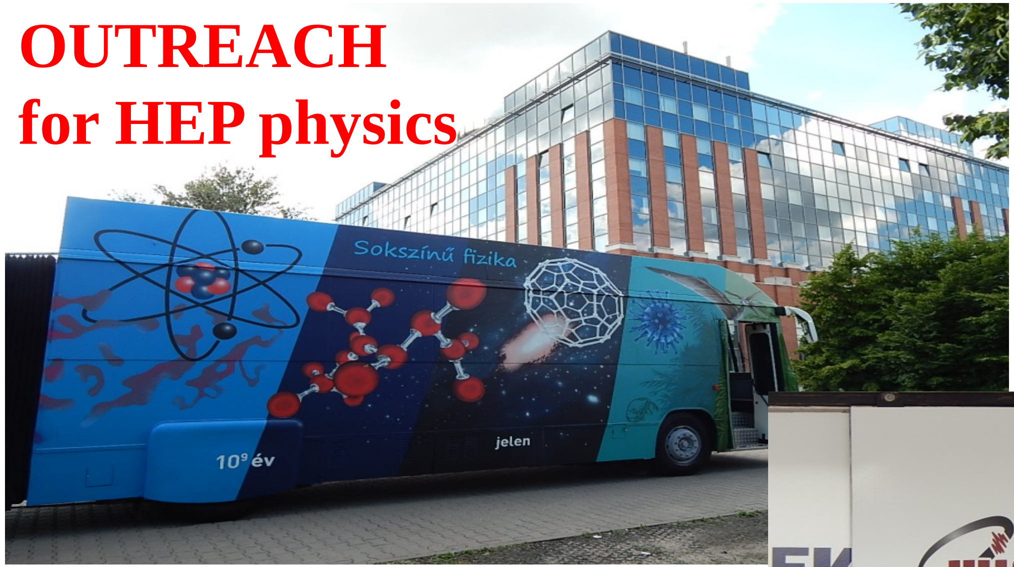
Relativistic interactions

Interactions occurring between high intensity laser pulses (TW, PW) and matter evolve on the atomic (femto-second, atto-second) time scale. The investigation of these processes requires a high intensity triggering laser pulse together with a synchronized “probing” attosecond pulse. Precisely this combination is expected from the ELI infrastructure in Szeged, allowing for example **studies of laser particle-acceleration**, nonlinear quantum electrodynamics.

Biological, medical and Industrial applications

ELI-ALPS will produce high-brightness, high repetition rate, extremely short laser-based X-ray pulses. Facility features will open new research fields, and make new approaches feasible. Possible application areas include biomedical sciences, chemistry, climate research, energy, development of new materials, semiconductors, optoelectronics, and many more.

OUTREACH
for HEP physics



All Colors of Physics Bus
National Physics RoadShow

Inauguration: April 2014
Rolf Heuer CERN DG

Future big projects – including Wigner

1. CERN FCC

2. ELI super-lasers

3. Einstein Telescope
   - gravitational wave research (TH)
   - new IT-solutions, Big Data, HTC
   - seismology, engineering
   - innovative technologies

Wigner Theory & Computing & Experiment groups

Hungarian ALICE Group

Experiment: Gy. Bencédi, L. Boldizsár, E. Dávid, E. Frajna, Á. Gera, G. Hamar, J. Imrek, T. Kiss, M. Varga-Kőfaragó, P. Lévai, M. Nguyen, B. Szilágyi, D. Varga, Z. Varga, O. Visnyei, R. Vértesi

Wigner GPU Laboratory

Computing: D. Berényi, BM. Nagy-Egri, B Kacskovics

Heavy-ion Theory Group, Department for Theoretical Physics

Theory: D. Berényi, G. Bíró, T.S. Biró, B. Csurgay-Horváth. V. Gogokhia, P. Lévai, P. Pósfay, Á.Takács, M. Gyulassy, G.Y. Ma, G. Papp, K.M. Shen, X.N. Wang, B.W. Zhang.

MOTIVATION

Theoretical Investigations

Phases of the strongly interacting matter

- Investigations
  - High-pT @ perturbative QCD

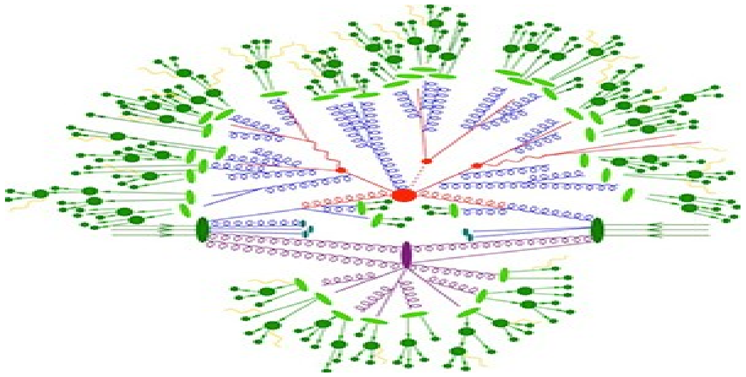
    High-energy nuclear effects

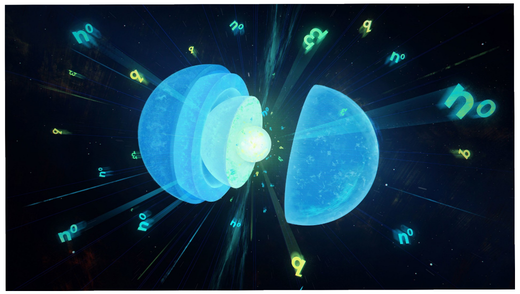
    Simulation of heavy-ion collisions
  - Non-perturbative QCD

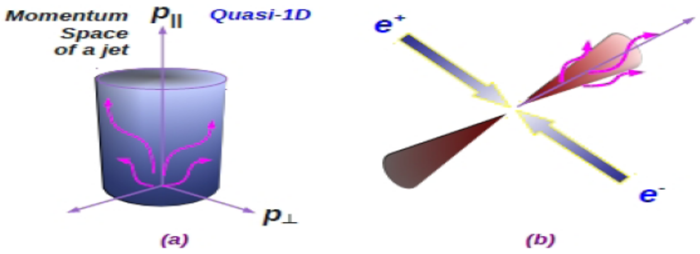
    Mass Gap & its Applications

    Modeling compact star interior (FRG)
  - New theoretical developments

    Hadronization within the non-extensive statistical phenomena



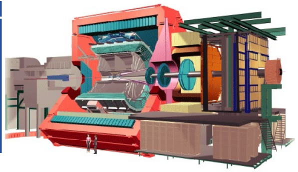




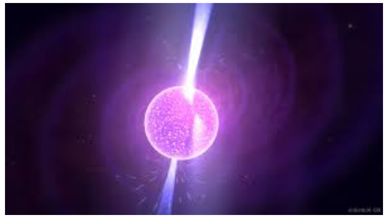
Main Research Directions

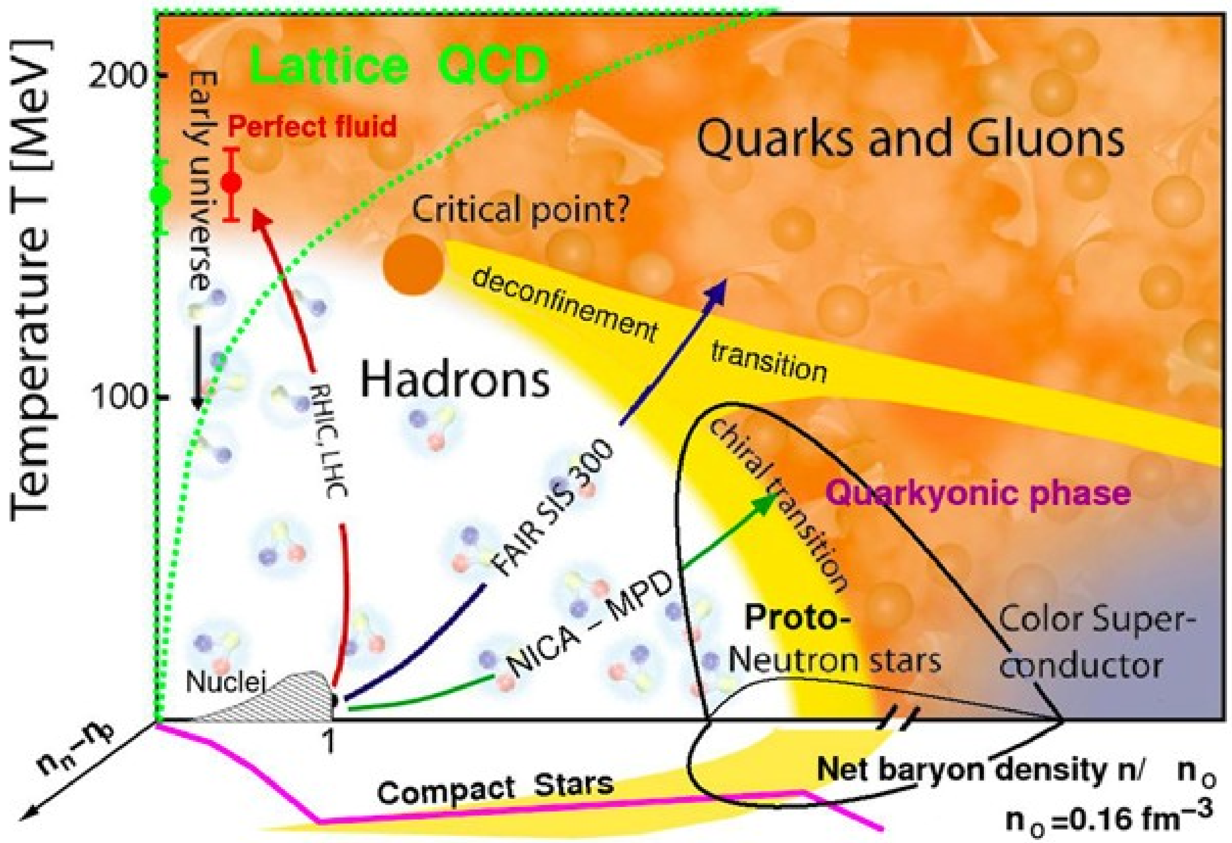
- Numerical QCD simulations (GPU)

- LHC ALICE FCC



- BES: Beam-Energy Scan (GSI/FAIR, NICA)
- Theory of Compact Stars





Heavy Ion Theory Research Group

- Investigation of Low Energy Hadron Spectra
  - Low energy hadron spectra, SU(3)xSU(3) symmetric sigma model, transport code; GSI HADES experiments theoretical background

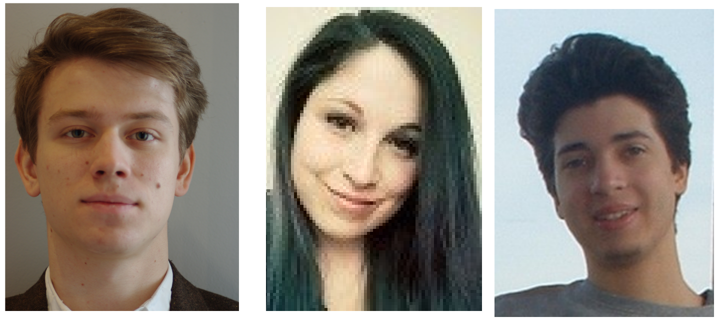
    Wolf Gy, Kovács P, Zétényi M, Almási G, Balassa, Jóföldi Zs, Váróczy J.
- Perturbative and non-perturbative QCD
  - Perturbative QCD: nuklear effects in high-energy collisions; Non-perturbative QCD, mass gap, equation of state; theoretical background for ALICE

    BGG, Gyulassy M, Vaghtang G, Pósfay P, Karsai Sz, Berényi D, Biro G, Takács Á
- Modelling Hadronization and Fragmentation
  - Hadronization models by Tsallis-Pareto like distributions, jet-fragmentation and fragmentation functions

    BGG, Biró TS, Shen K-M, Bíró G, Takács Á
- New Thermodynamical Approaches
  - Non-extensive thermodynamics, hidrodinamical and statistical approaches, Unruh effect, termodynamics in curved space-time

    Bíró TS, BGG, Ván P, Ürmössy K, Kovács R.

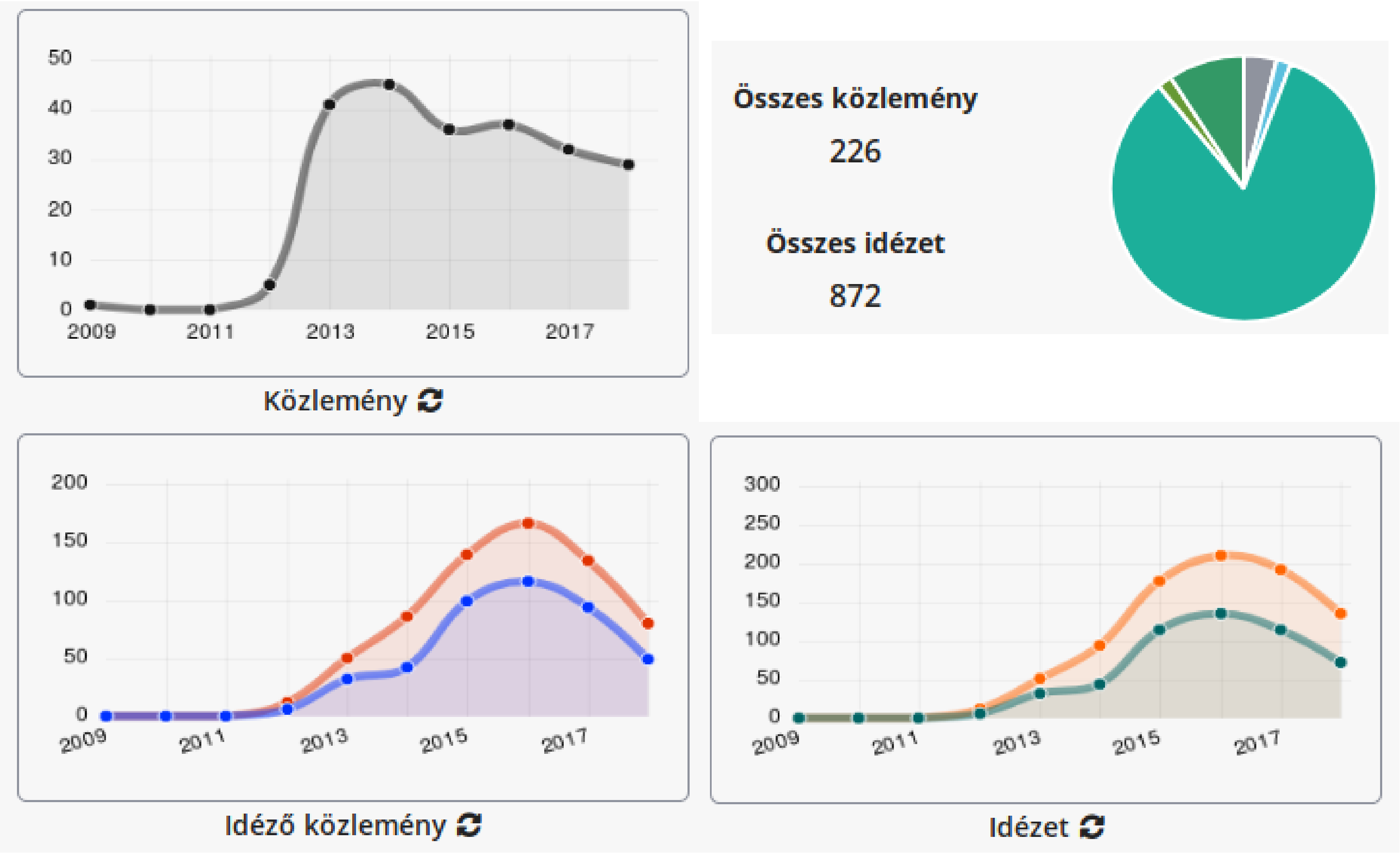
Heavy-Ion Wigner Research Group 2019



+ more younger students...

Publications of Heavy-Ion Research Group

MTMT(2):



Publications (for 2018) 38

- 28 Sci
- 10 conference contribution
- 77.49 Impact Factor
- 104 MTMT (167 INSPIRE)

Presentations (for 2018) 85 (2018)

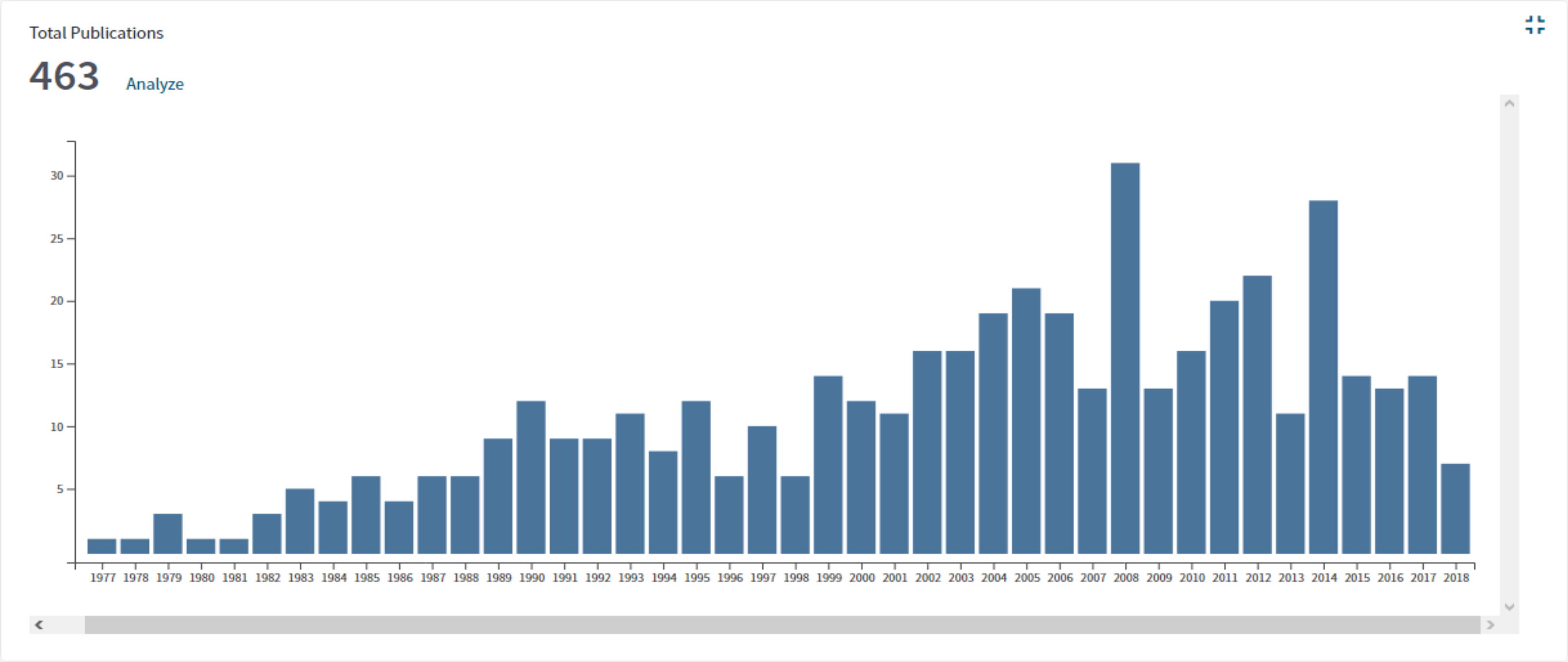
- 24 invited talk
- 49 international conferences
- 25 Hungarian event
- 11 poster

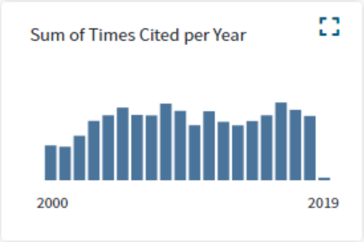
Publications (2019)

- 6 published
- 4 accepted for pub
- 4 submitted

Publications of Heavy-Ion Research Group

WoS





h-index
49
Average citations per item
23,03

Sum of Times Cited
10 664
Without self citations
9 520

Citing articles
6 547 Analyze
Without self citations
6 223 Analyze

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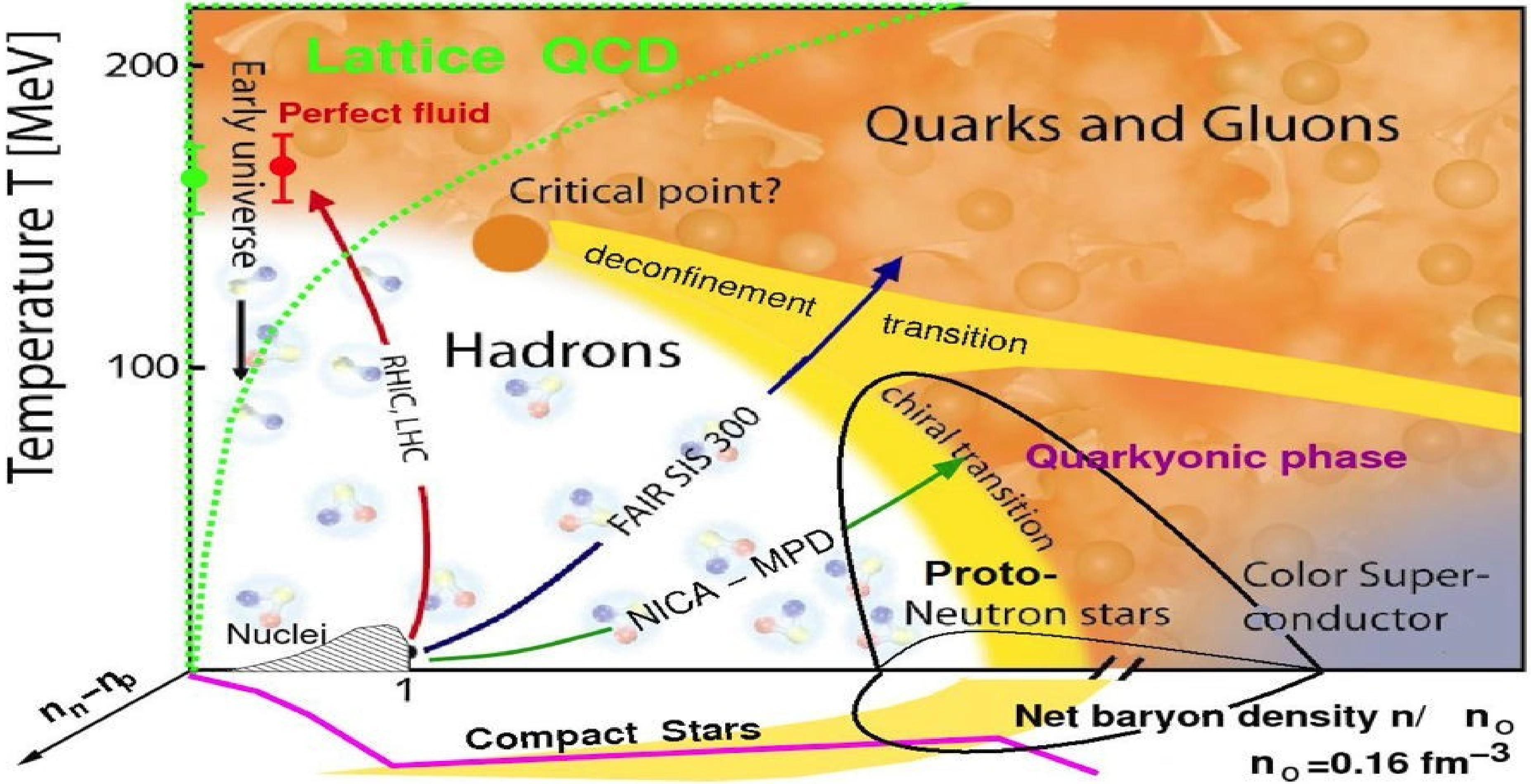
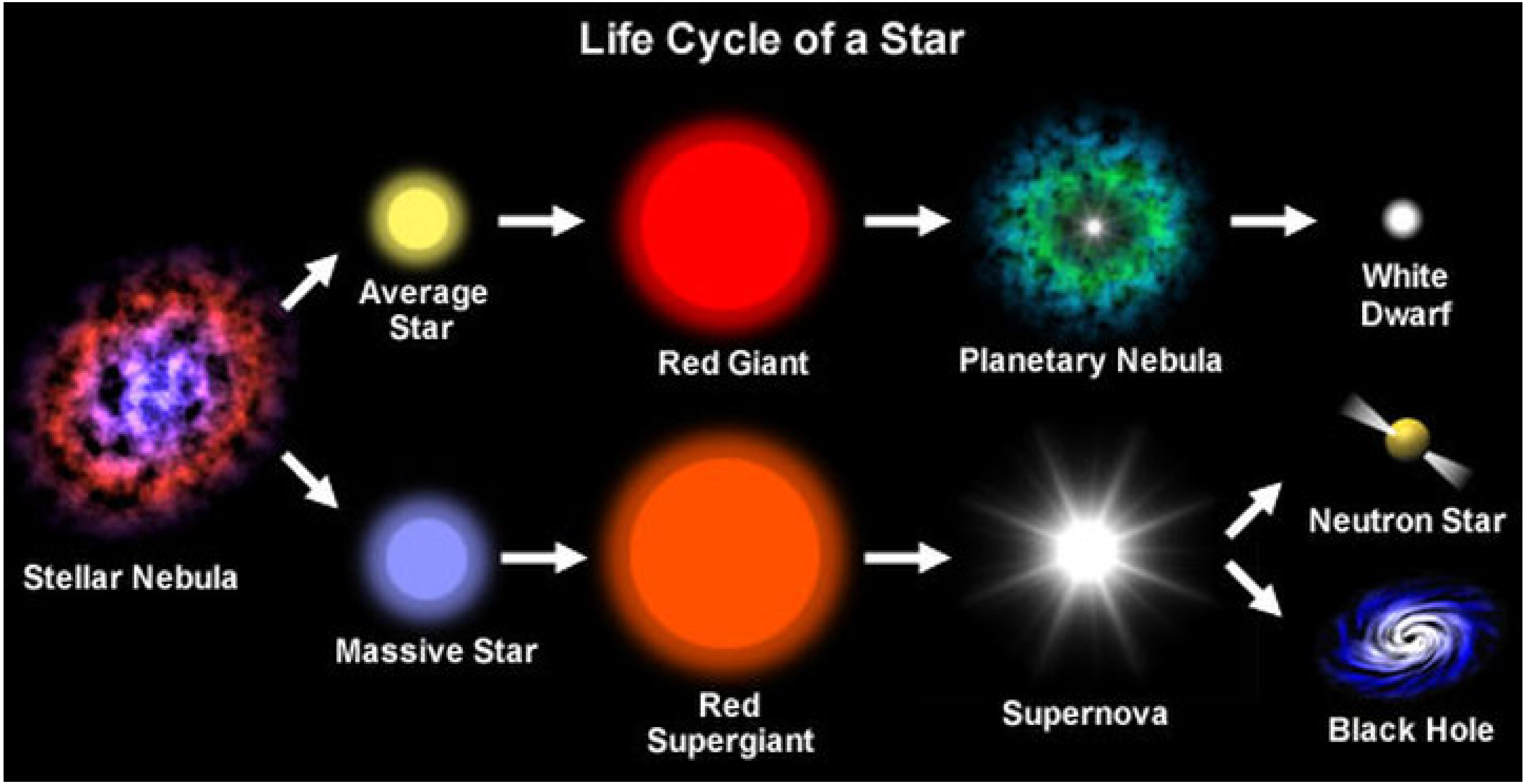
The phases of the strongly interacting matter

- Extreme dense & cold matter: COMPACT STAR EoS



The inner structure of compact stars



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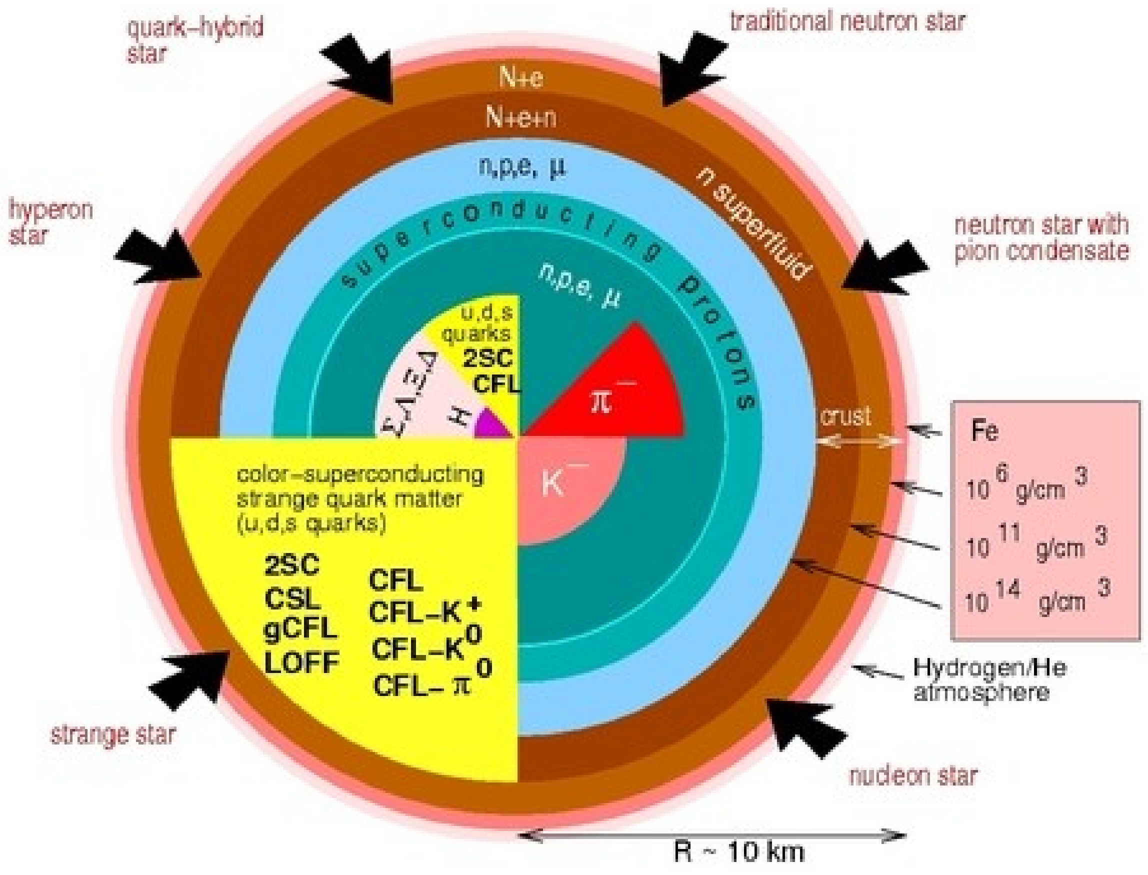
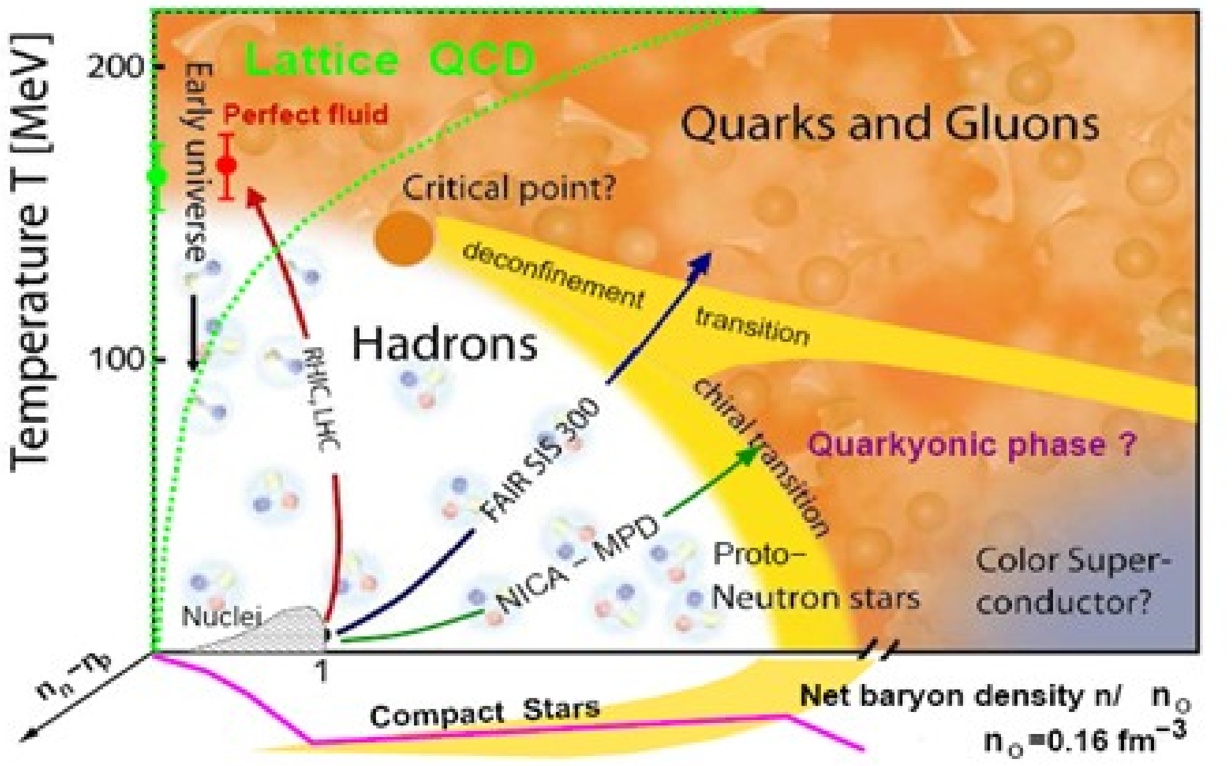
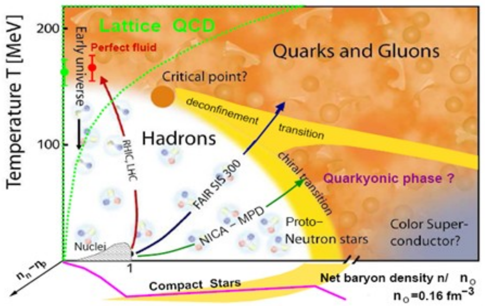
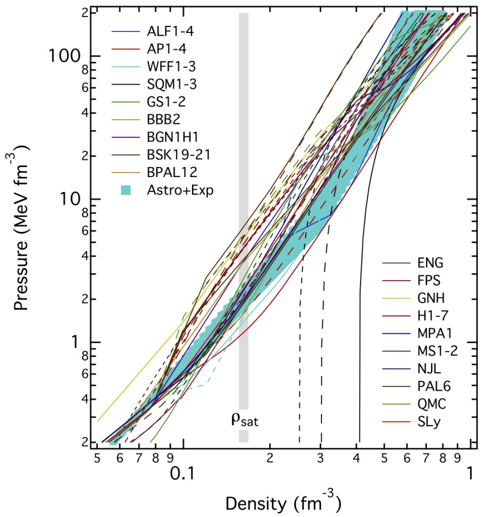




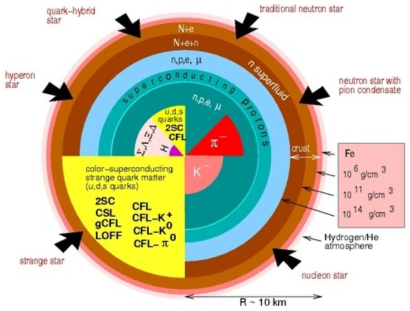
The inner structure of compact stars

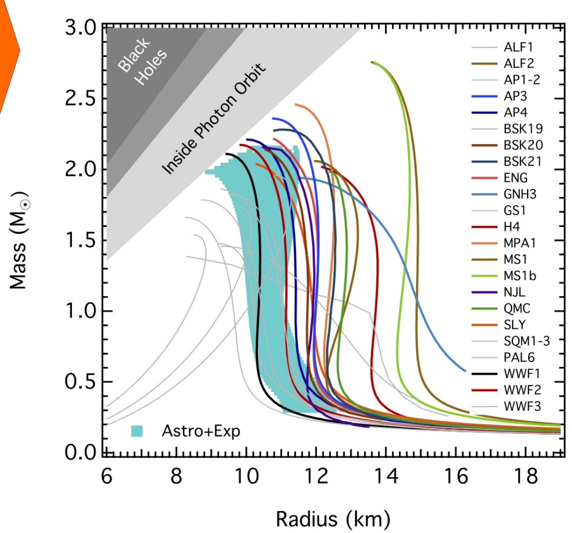
EoS from exp & theory



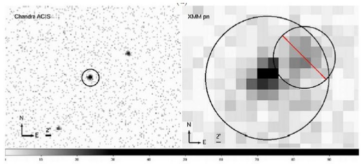


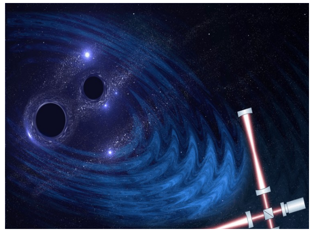
Application in compact stars

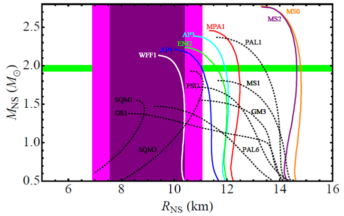


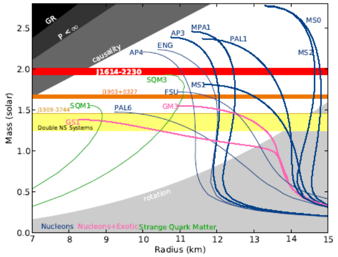


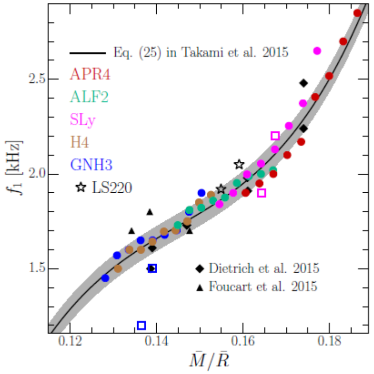
Constraints by astrophysical observations





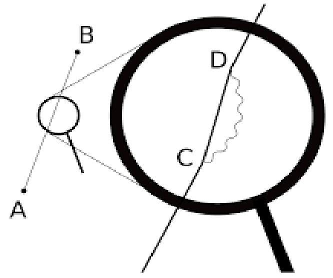






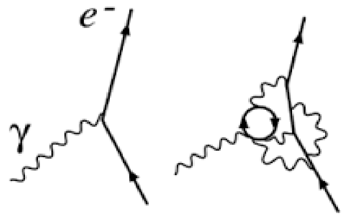
The inner structure of compact stars

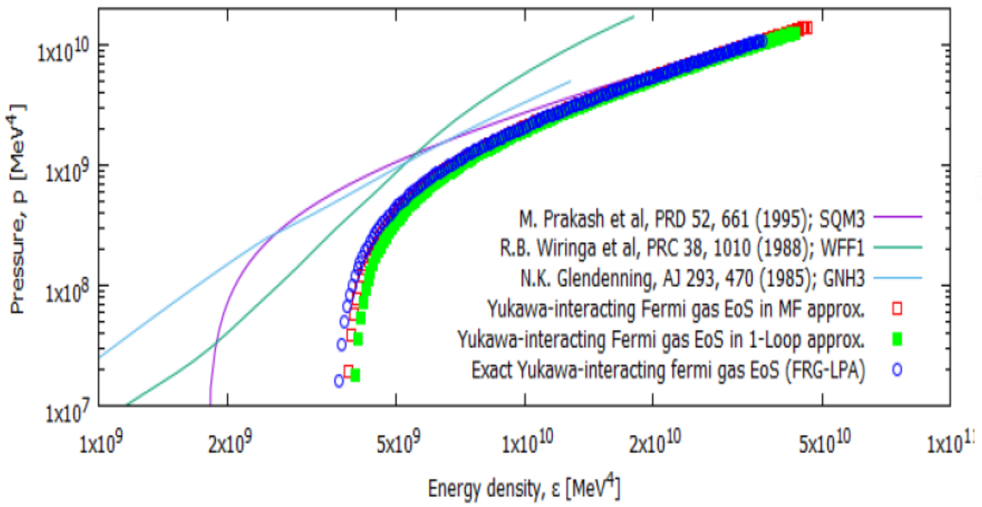
- It is hard to get effective action for an interacting field theory: e.g.: EoS for superdense cold matter ($T \rightarrow 0$ and finite μ)
- Taking into account quantum fluctuations using a scale, k
  - Classical action, $S = \Gamma_{k \rightarrow \Lambda}$ in the UV limit, $k \rightarrow \Lambda$
  - Quantum action, $\Gamma = \Gamma_{k \rightarrow 0}$ in the IR limit, $k \rightarrow 0$
- FRG (non-perturbative) Method: Smooth transition from macroscopic to microscopic world using the scale

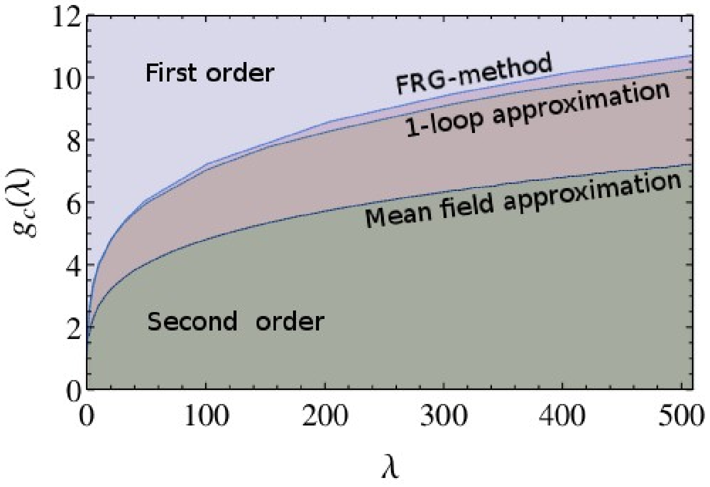


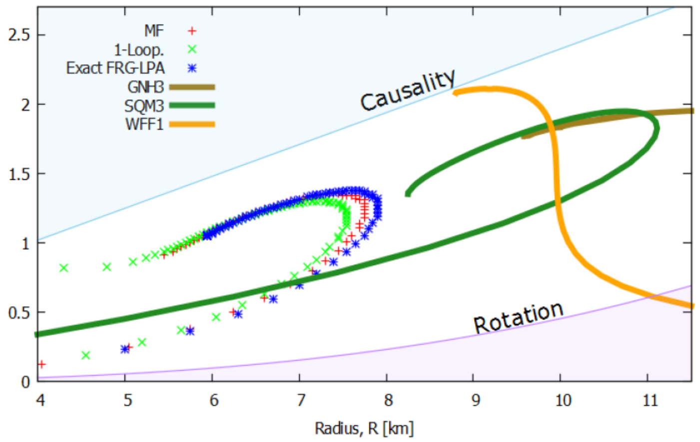
scale, k

$\Lambda \longrightarrow 0$



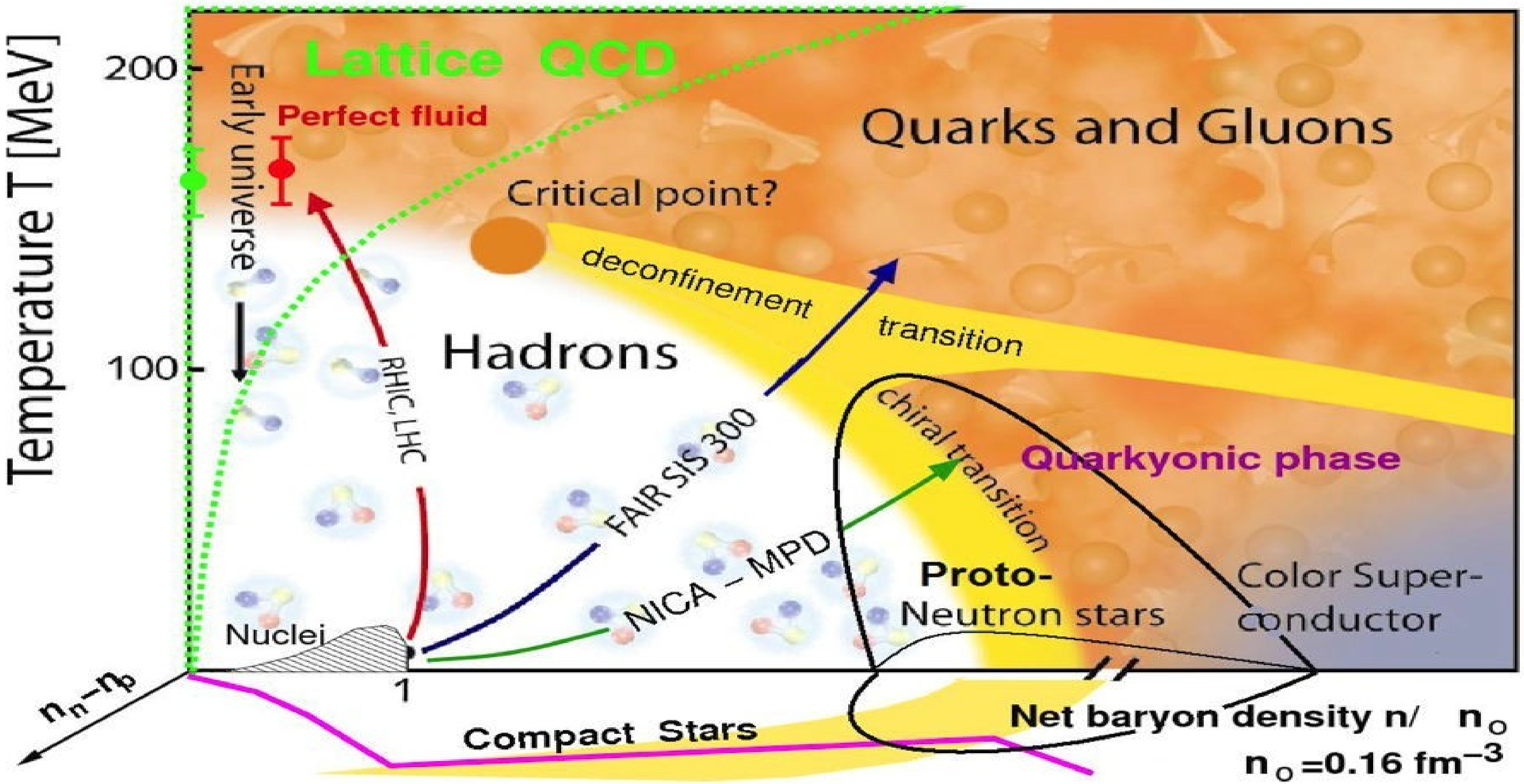






The phases of the strongly interacting matter

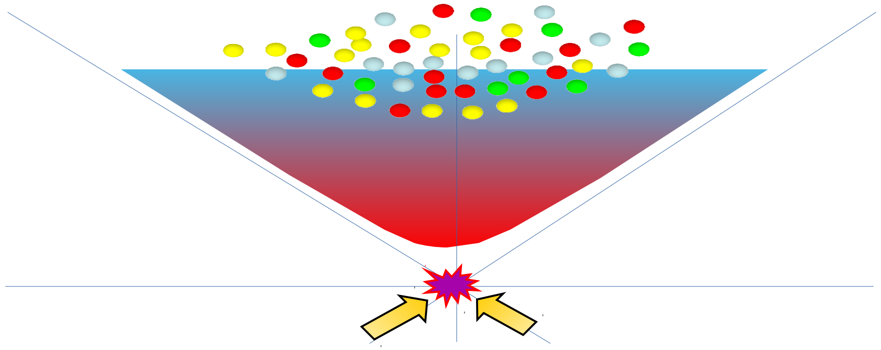
- Extreme hot & dense matter: HADRONIZATION



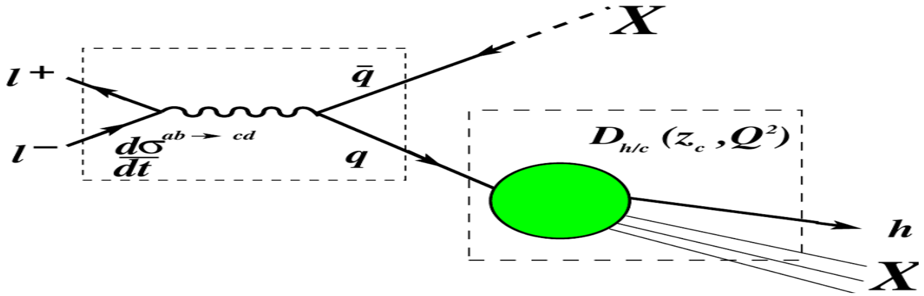
The phases of the strongly interacting matter

- Extreme hot & dense matter: HADRONIZATION

In high-energy collisions, hadron appears at the end of the partonic (q,g) processes.

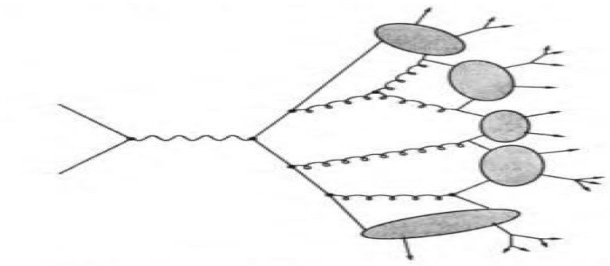


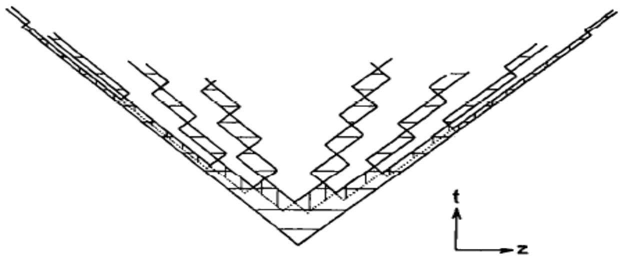
The description of the transition of partons → hadrons is still a mistery → phenomenology models are exist



Models for fragmentation:

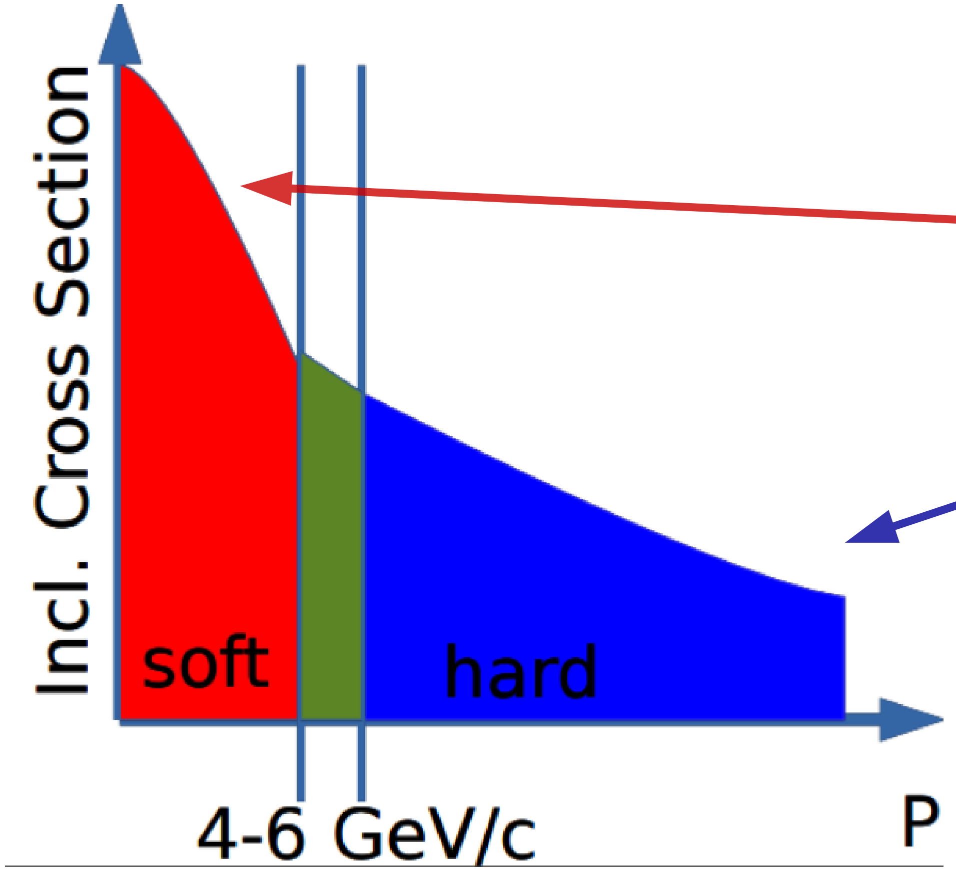
Feynman, Lund, string ,cluster, etc.





Hadronization by Tsallis-Pareto distributions

Proton-proton collisions identified,inclusive hadron spectra



Low p_T ~ Thermal models

$$\sim e^{-\beta p_T}$$

$$\sim p_T^{-\alpha}$$

High p_T ~ pQCD

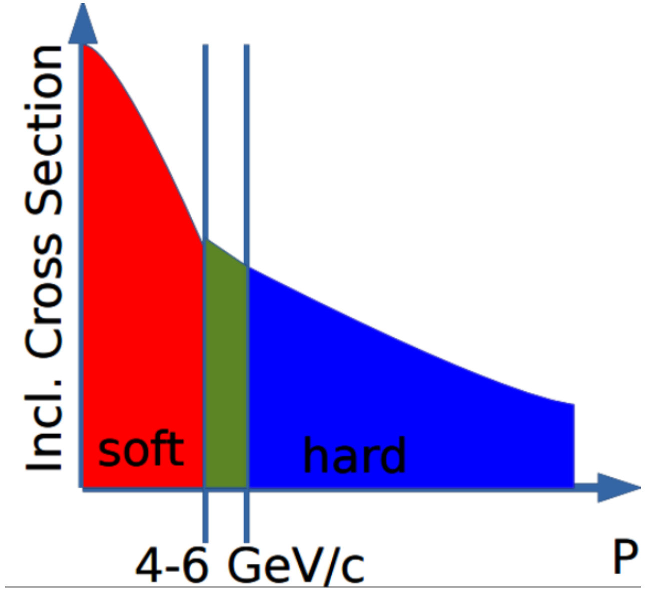
Hadronization by Tsallis-Pareto distributions

Experimental observation: Tsallis-Pareto momentum distribution

$$\frac{\mathrm{d}\sigma}{\mathrm{d}p_T} \sim \left[1 + \frac{q-1}{T}\varepsilon\right]^{-\frac{1}{q-1}}$$

Low p_T: $\sim e^{-\varepsilon/T}$

High p_T: $\sim \varepsilon^{-\frac{1}{q-1}}$



T – parameter (body): Soft p_T

q – parameter (tail): Hard p_T

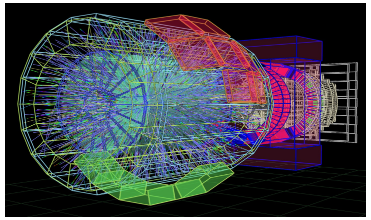
Hadronization by Tsallis-Pareto distributions

Extensive statistics: $S_{12} = S_1 + S_2$

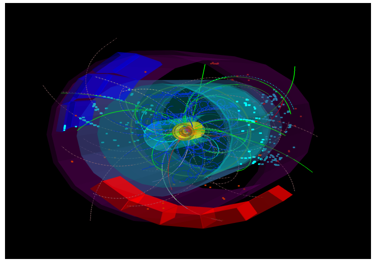
$$S_S = -\sum_i p_i \ln p_i$$

Boltzmann-Gibbs distr.: $\sim e^{-\beta\varepsilon}$

Non-extenzive statistic: $S_{12} = S_1 + S_2 + (q-1)S_1 S_2$



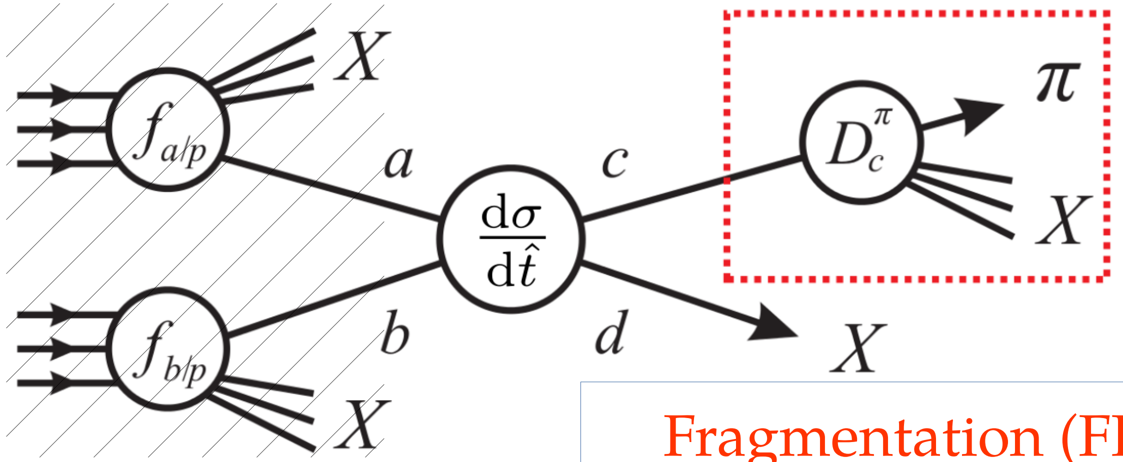
q-entropy: $$S_q = \frac{1}{q-1}\left(1 - \sum_1 p_i^q\right)$$



Tsallis-Pareto distribution:

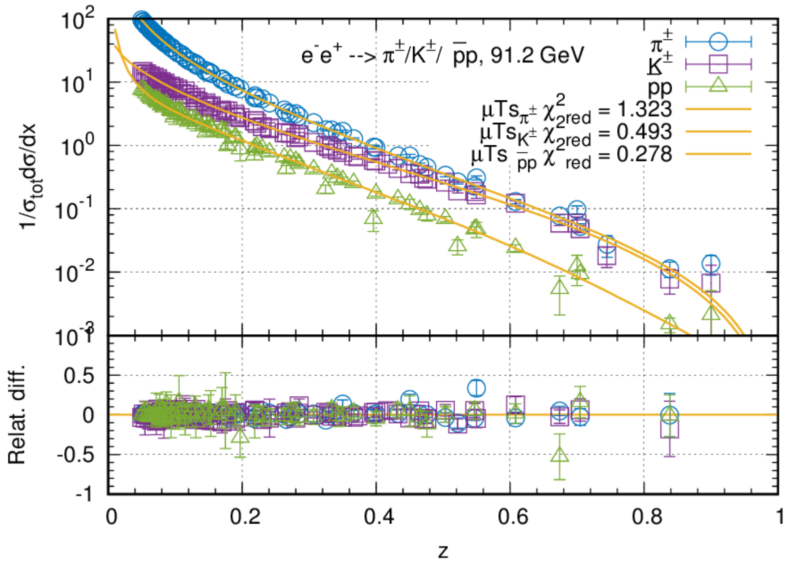
$$\sim \left[1 + \frac{q-1}{T}\varepsilon\right]^{-\frac{1}{q-1}}$$

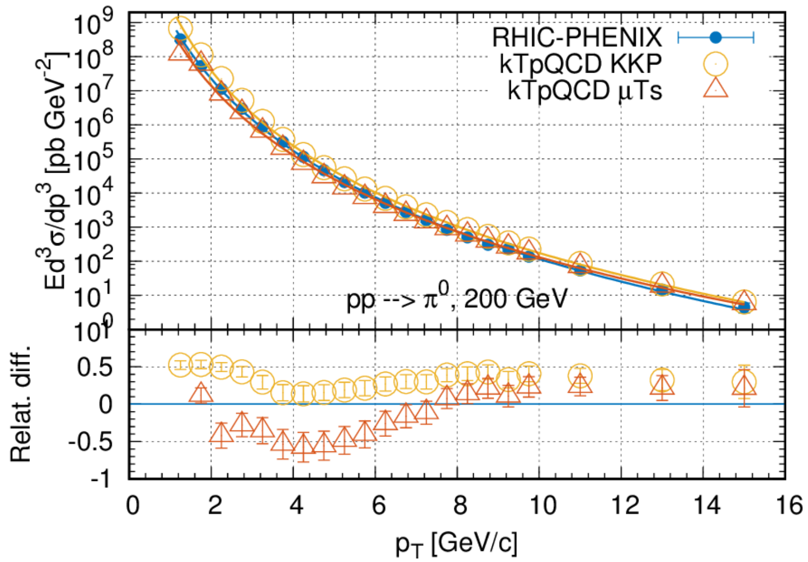
Hadronization by Tsallis-Pareto distributions



Fragmentation (FF)

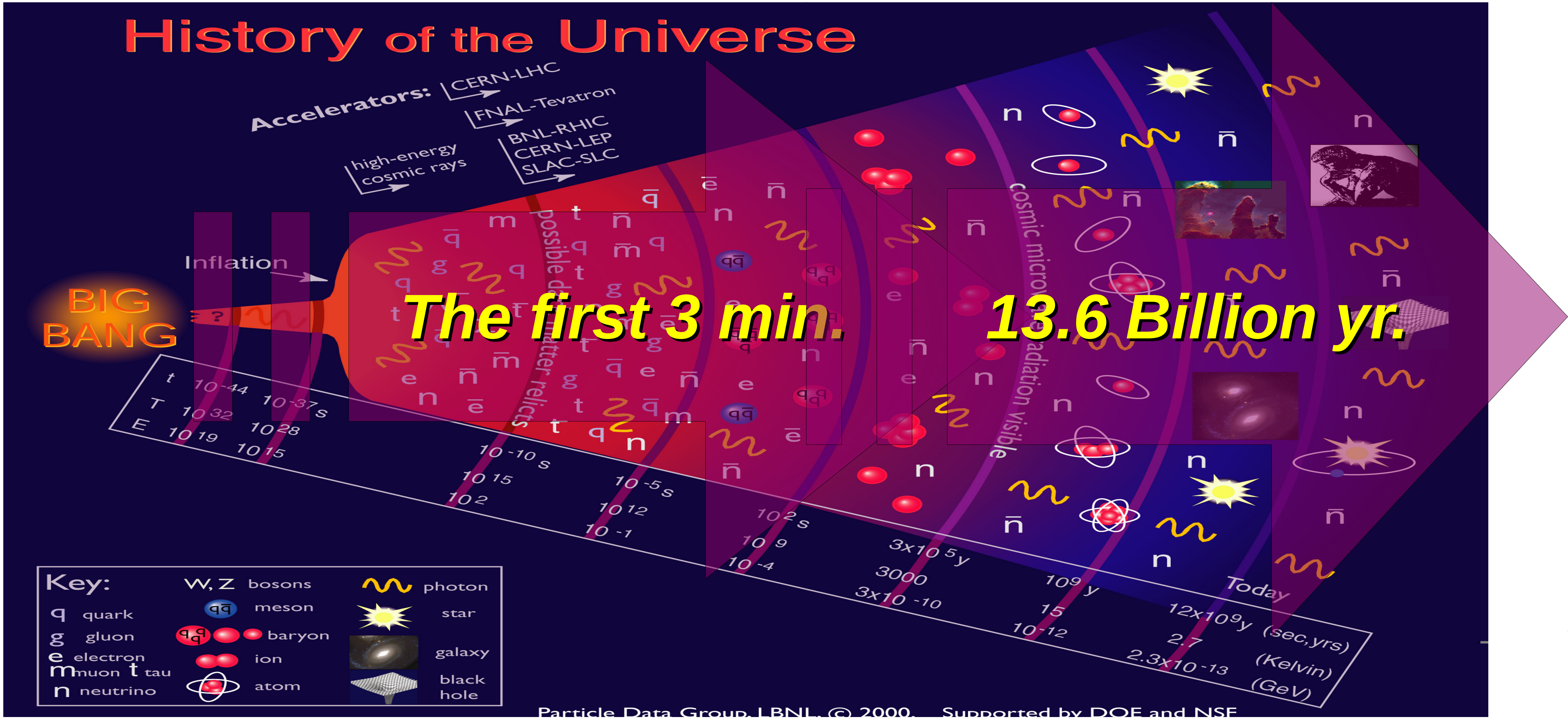
$$\sim (1-z)\left[1 - \frac{q-1}{T}\frac{\sqrt{s}}{2}\log(1-x)\right]^{-\frac{1}{q-1}}$$



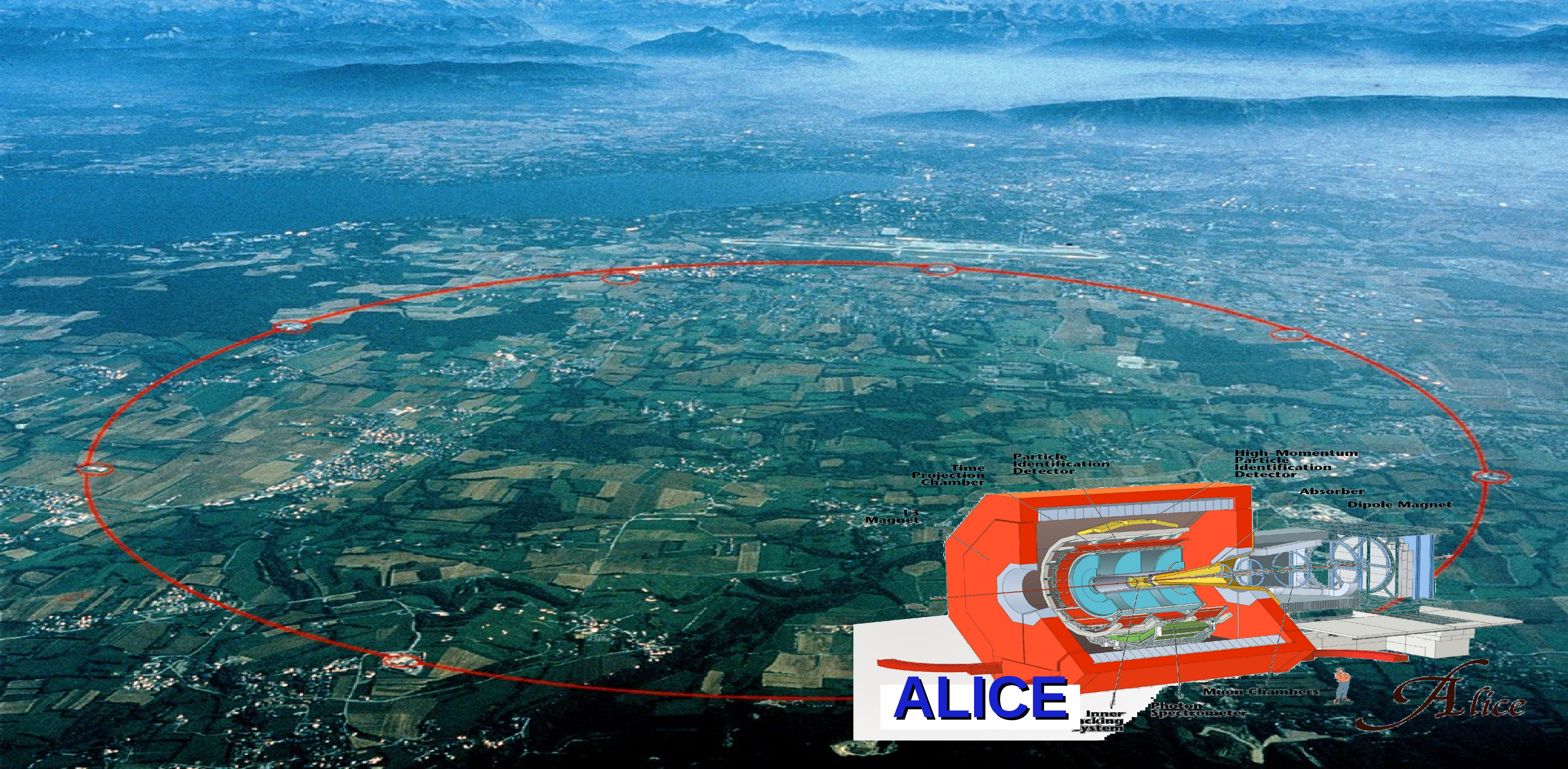


High-energy Heavy Ion Physics with ALICE Experiment at the LHC

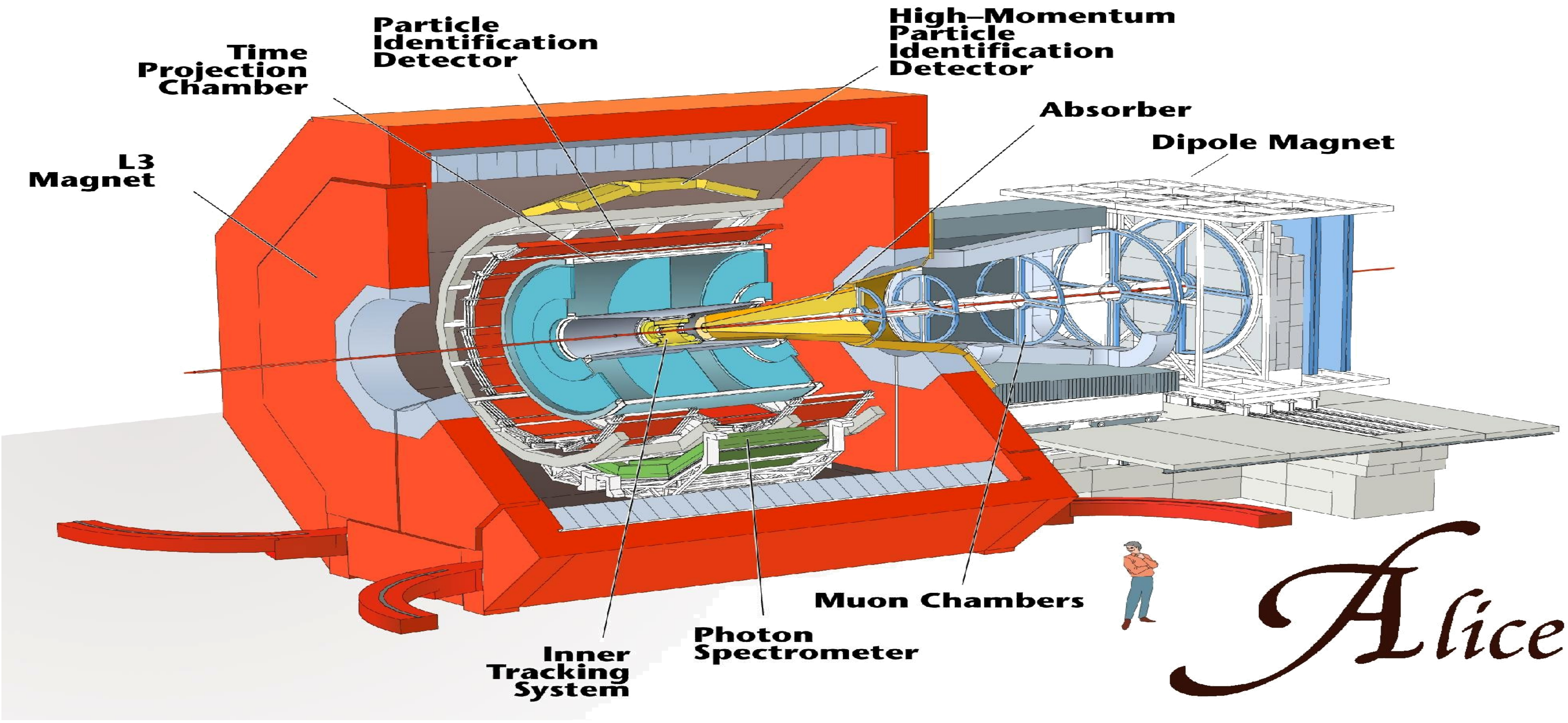
HIC: Research of the early Universe



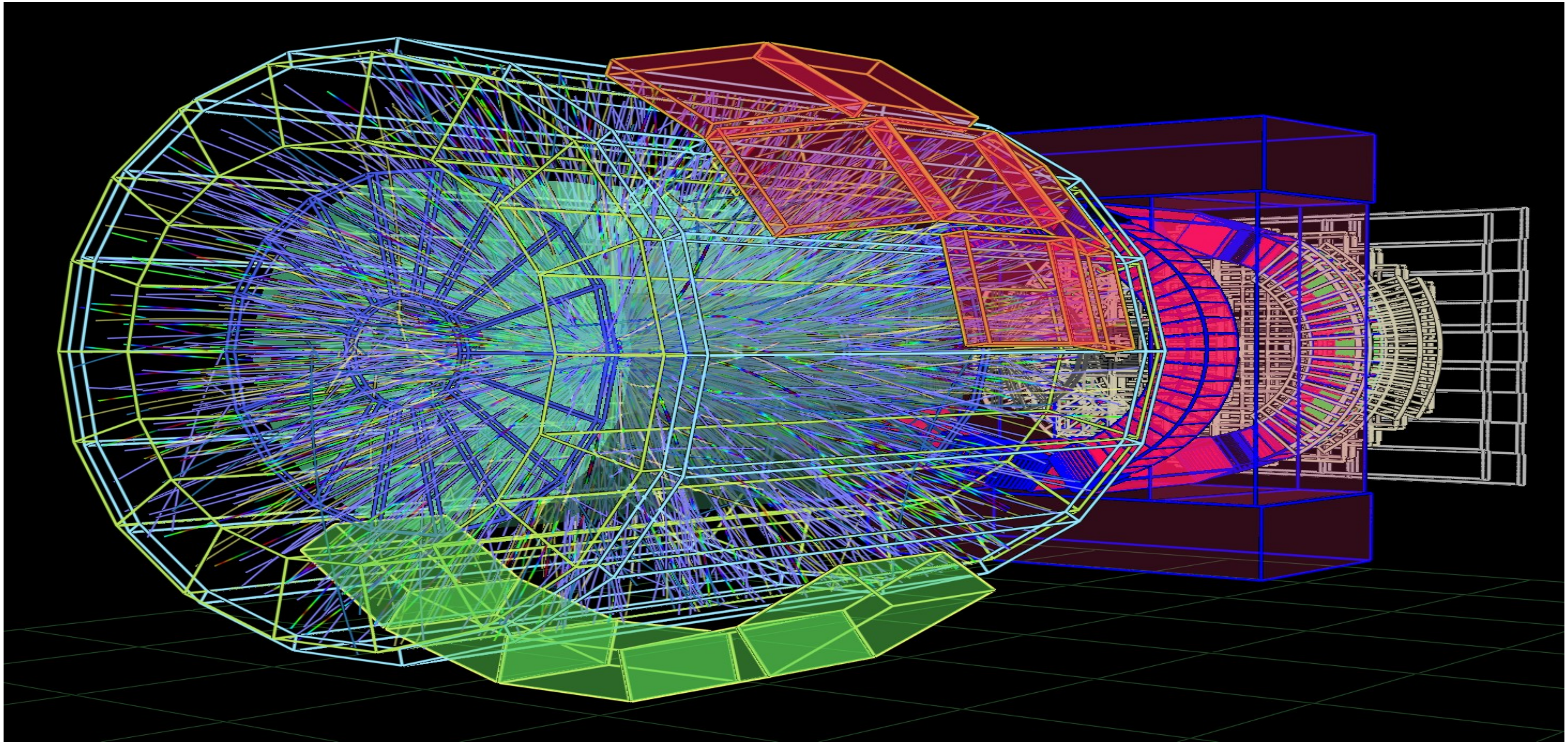
The Big Bang Experiment at LHC P2: ALICE



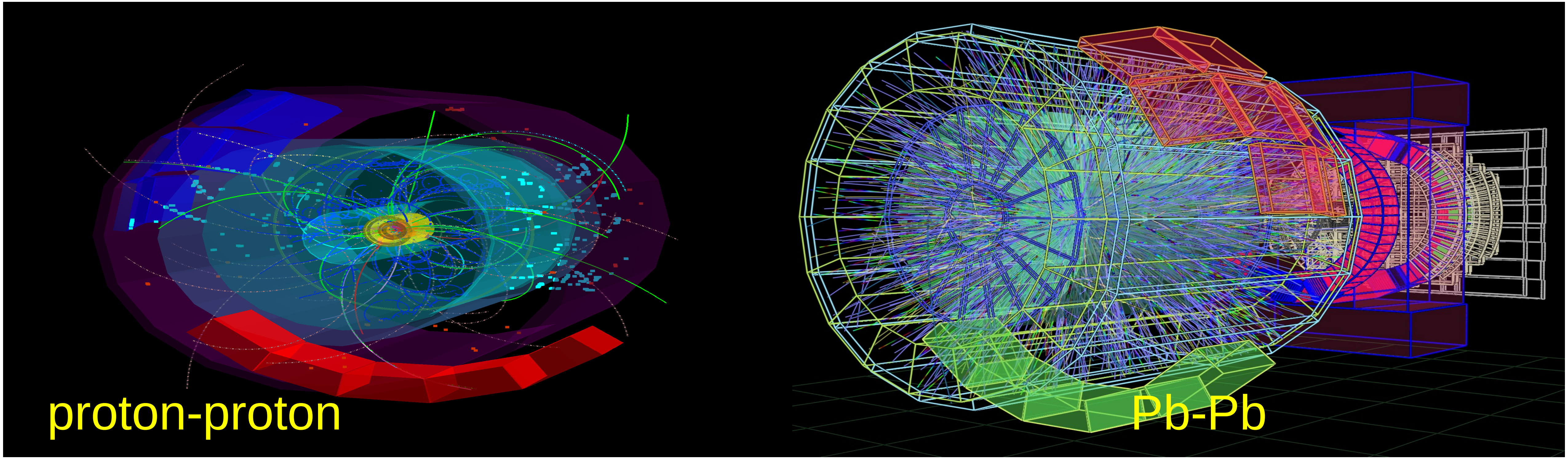
The structure of the ALICE detector



ALICE: Properties of the Primordial Matter



ALICE: Search for the perfect fluid...



Quar-Gluon Plasma (QGP):

- proton-proton vs. Pb-Pb
- hot, color (quark+gluon)
- superfluid
- This is a „perfect fluid“...

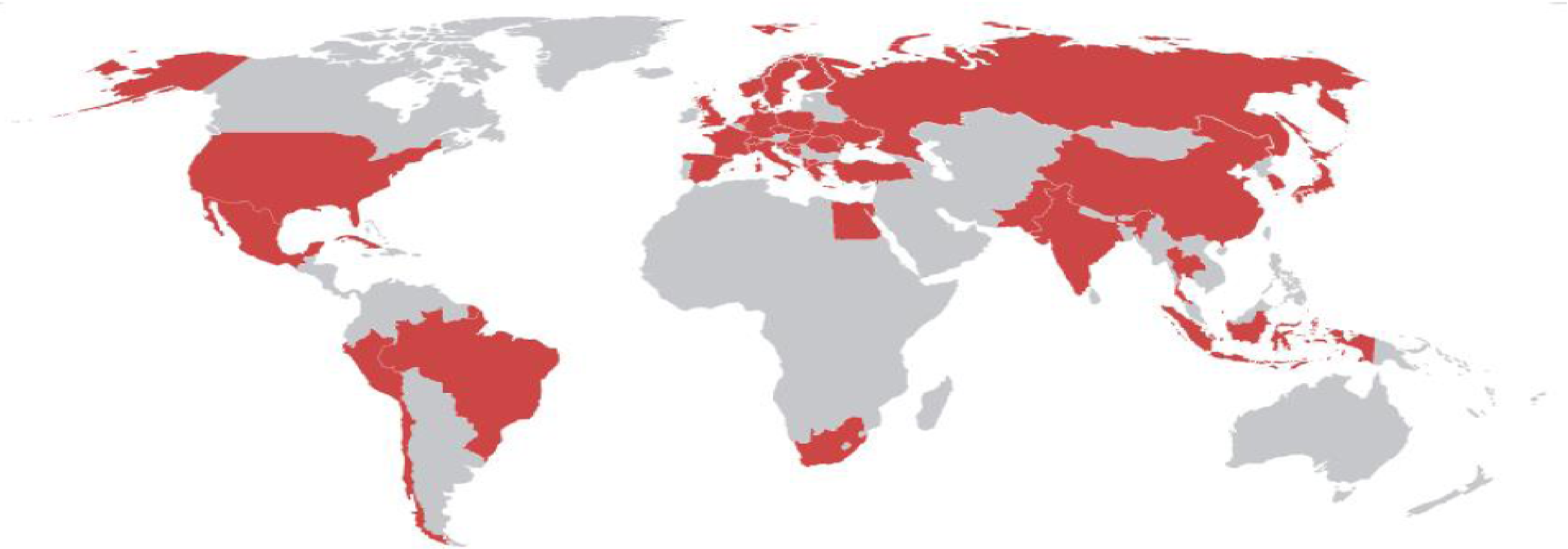
The Hungarian ALICE Group

Hungarian ALICE Group, Wigner RCP of the HAS, Budapest Hungary

A Large Ion Collider Experiment

THE ALICE COLLABORATION

36 COUNTRIES – 151 INSTITUTES – 161’451 KCHF CAPITAL COST



HUNGARIAN COLLABORATORS

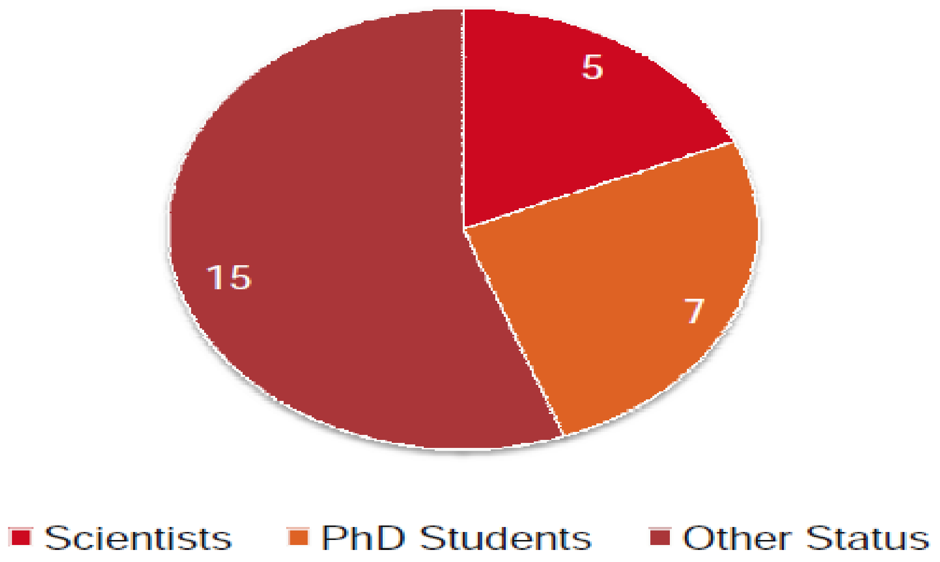
27 Collaborators coming from

Wigner Research Centre for Physics

of the Hungarian Academy of Sciences

Team leader: Gergely G. Barnaföldi

Collaborators by status



Hungarian ALICE Group, Wigner RCP of the HAS, Budapest Hungary

ALICE
A JOURNEY OF DISCOVERY

- DAQ – DAQ UG/service group
  - Strongly involved in the ALICE DAQ UG, CRU2 development
  - Kiss T, Dávid E, Imrek J, T.M. Nguyen
- P/A – Physics/Analysis group
  - High p_T, jets, PID, heavy quarks, correlation
  - BGG, Lévai P, Vértesi R, Varga-Kőfaragó M, Bencédi Gy, Szigeti B
- DDG – Detector Development group
  - Gaseous detector R&D, TPC UG,
  - Varga D, Boldizsár L, Hamar G, Gera Á
- GRID – ALICE Tier-2 Site
  - T2 Budapest: 1000 cores, 750 TB HDD
  - BGG, Bíró G

ALICE data analysis

ALICE data analysis – identified hadron spectra

- Measurement of high-pT hadron spectra with particle identfication (pion, kaon, proton)

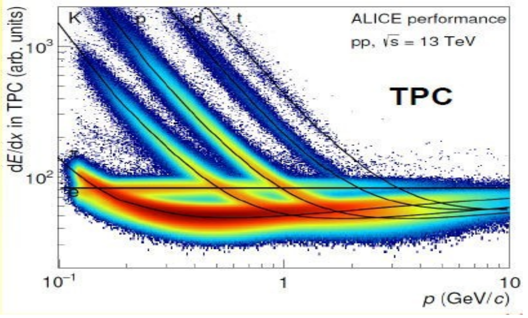
- Complex task, done by many detector:

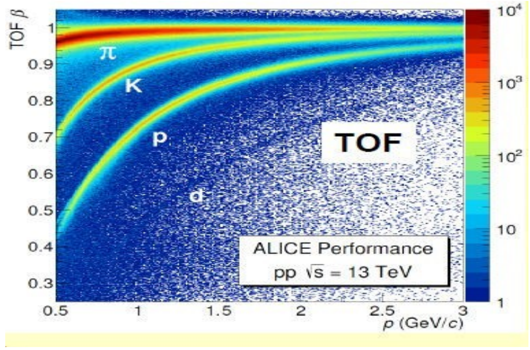
  TPC+TOF – Time Projection Chamber+Time of Flight
  - low p_T<1 GeV/c & high p_T> 5 GeV/c momentum region

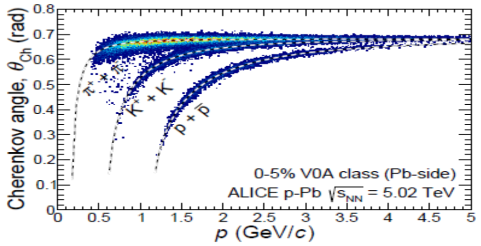
  HMPID – RICH, Cherenkov detector
  - 1GeV/c <p_T < 5 GeV/c intermediate momenum region

  ITS – Secondary vertex method

- Identified hadron spectra
  → mass & flavor, triggered correlations

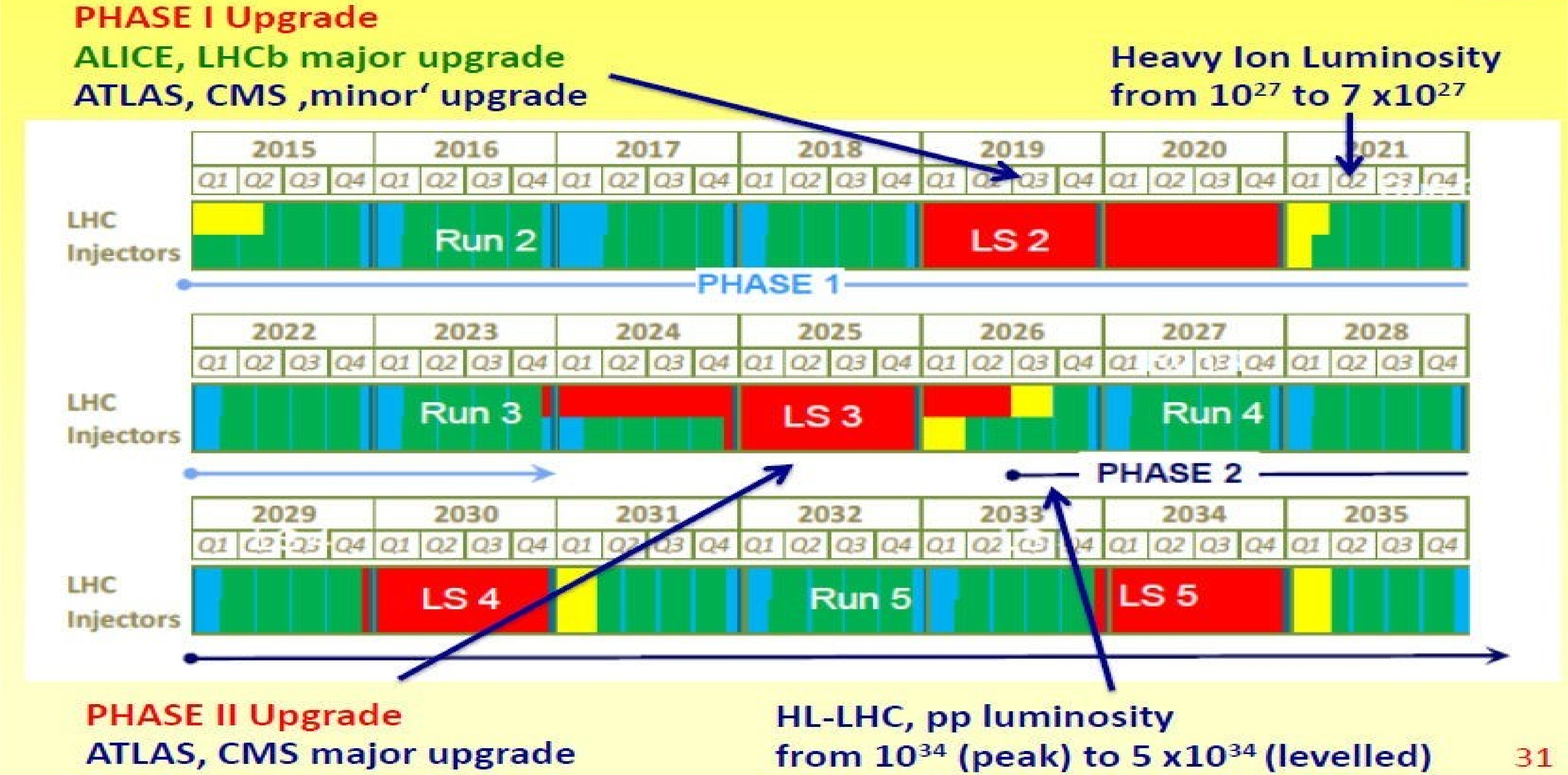




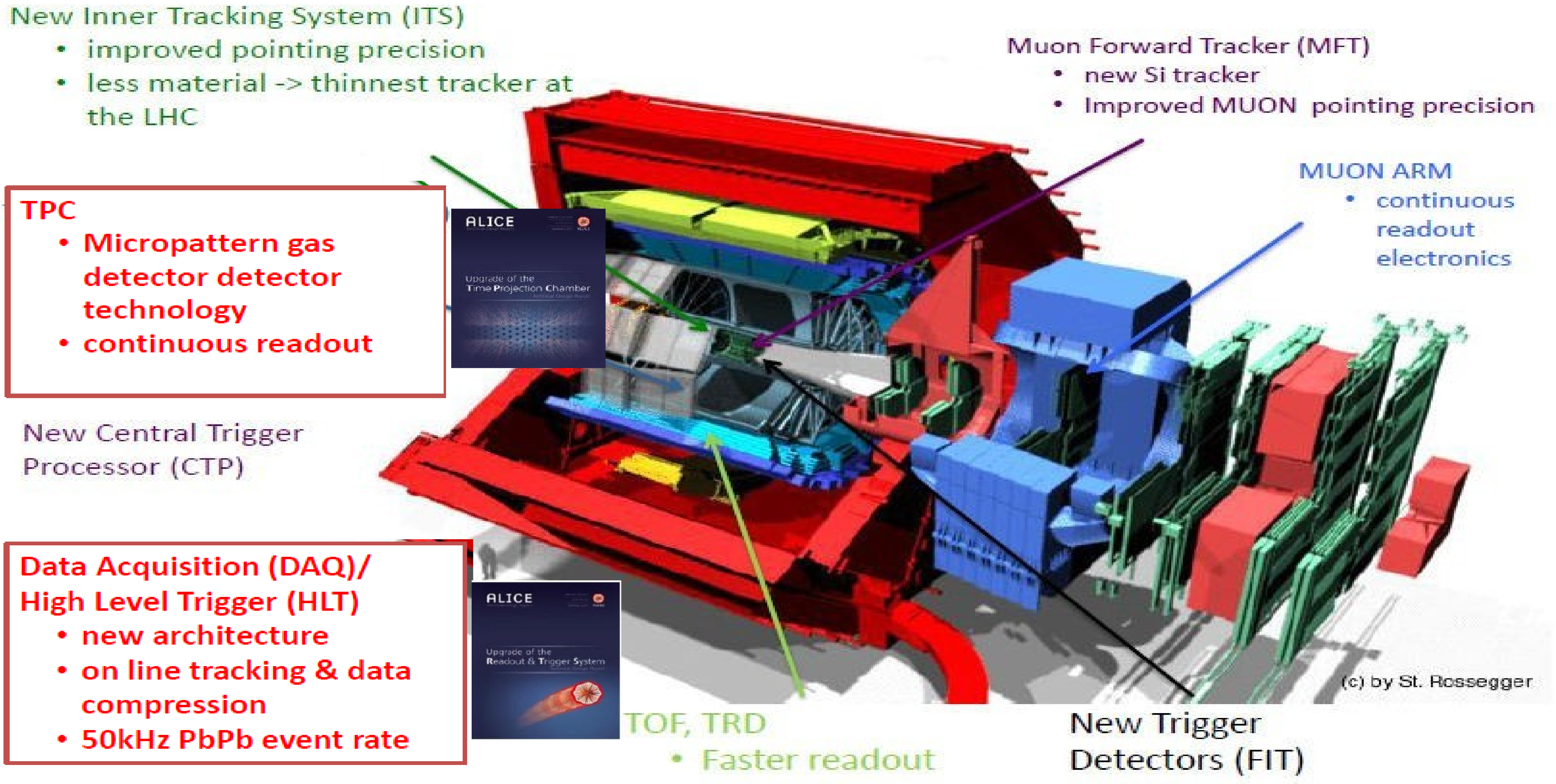


Participation in the ALICE upgrade (2018-2020)

The upgrade plane of the Large Hadron Collider (LHC)



The upgrade of the ALICE detector during LS2

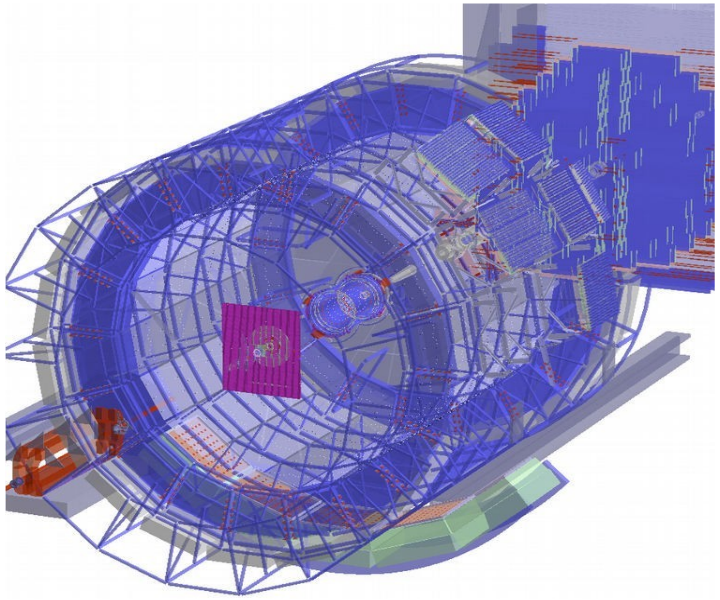


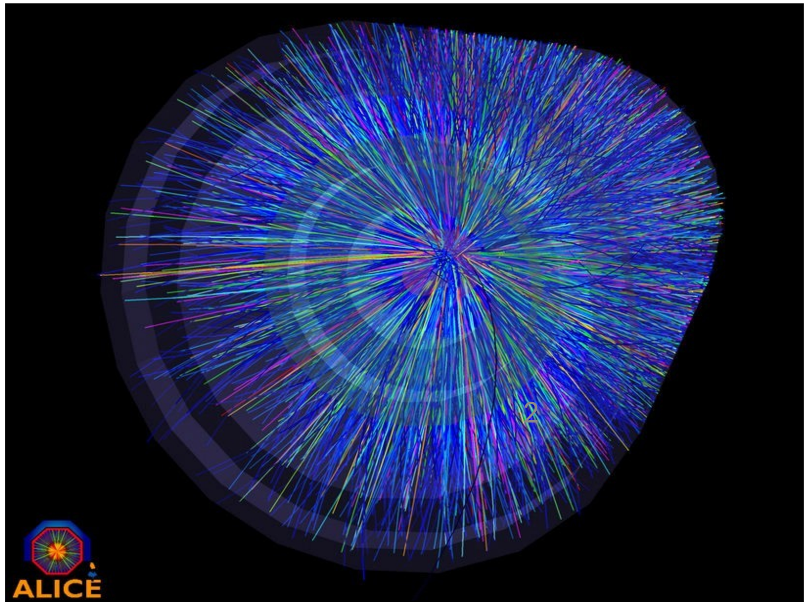
TPC
- **Micropattern gas detector detector technology**
- **continuous readout**

Data Acquisition (DAQ)/ High Level Trigger (HLT)
- **new architecture**
- **on line tracking & data compression**
- **50kHz PbPb event rate**

ALICE TPC: World’s Largest TPC

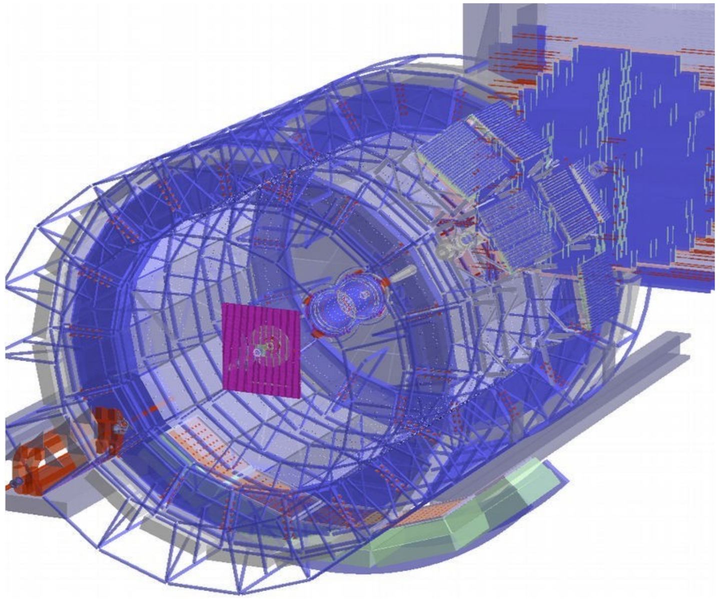
- Measuring the path of the particles with the World’s largest 90m3 Time Projection Chamber

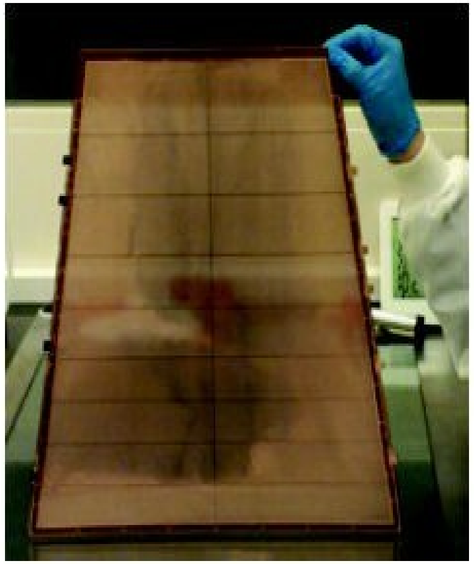


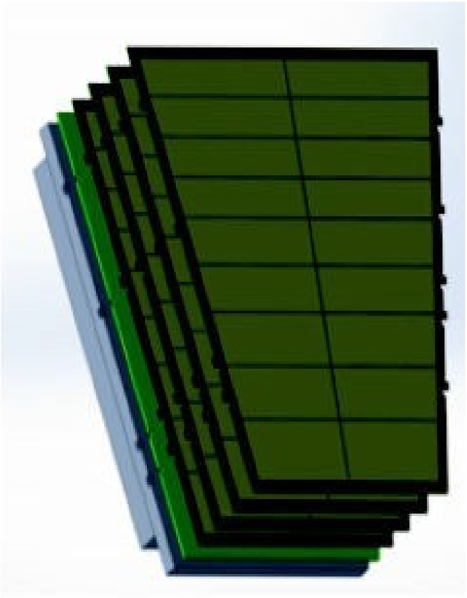


ALICE TPC: World’s Largest GEM-TPC

- Measuring the path of the particles with the World’s largest 90m3 Time Projection Chamber

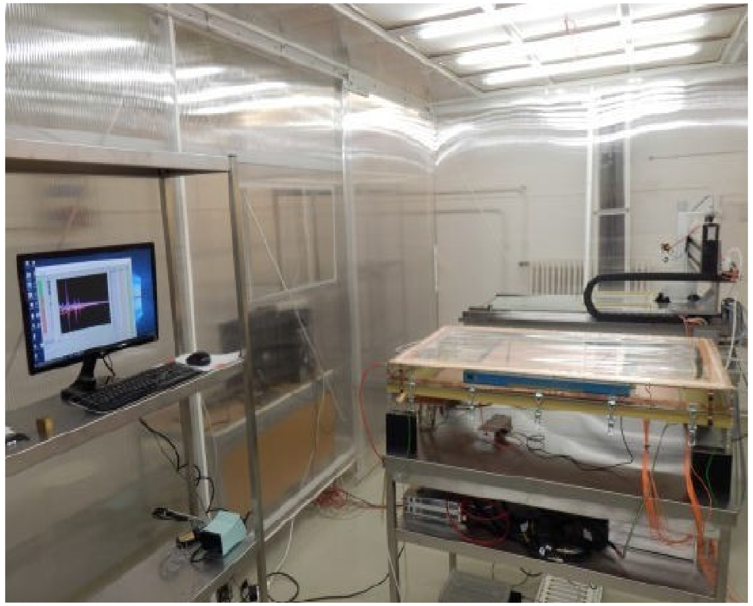


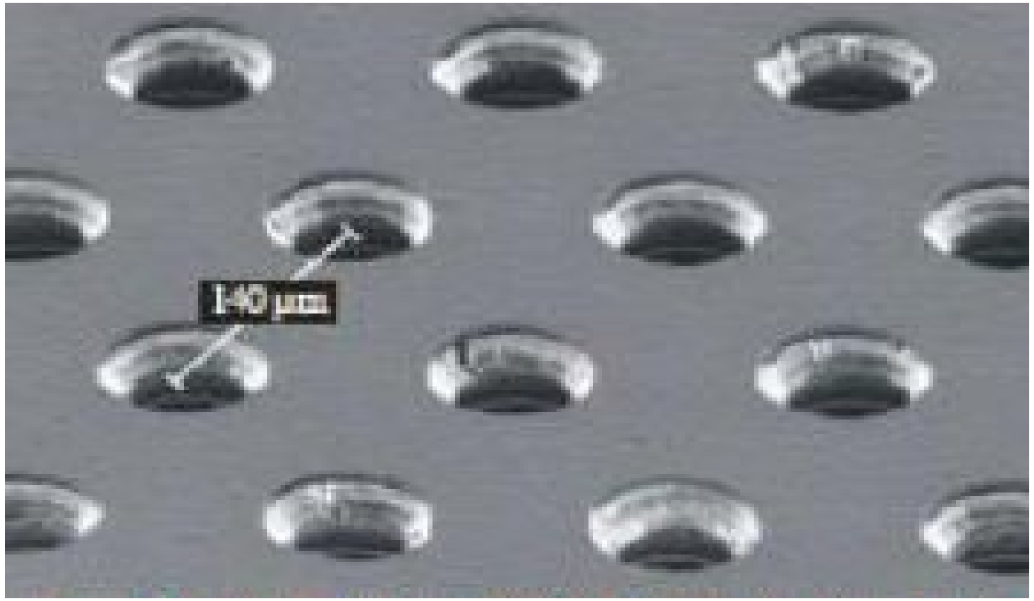




ALICE TPC: World’s Largest GEM-TPC

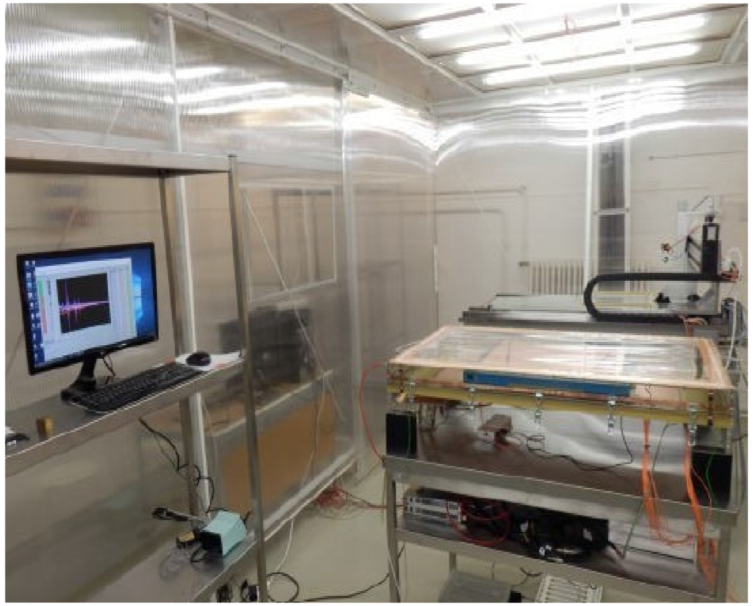
- Measuring the path of the particles with the World’s largest 90m3 Time Projection Chamber

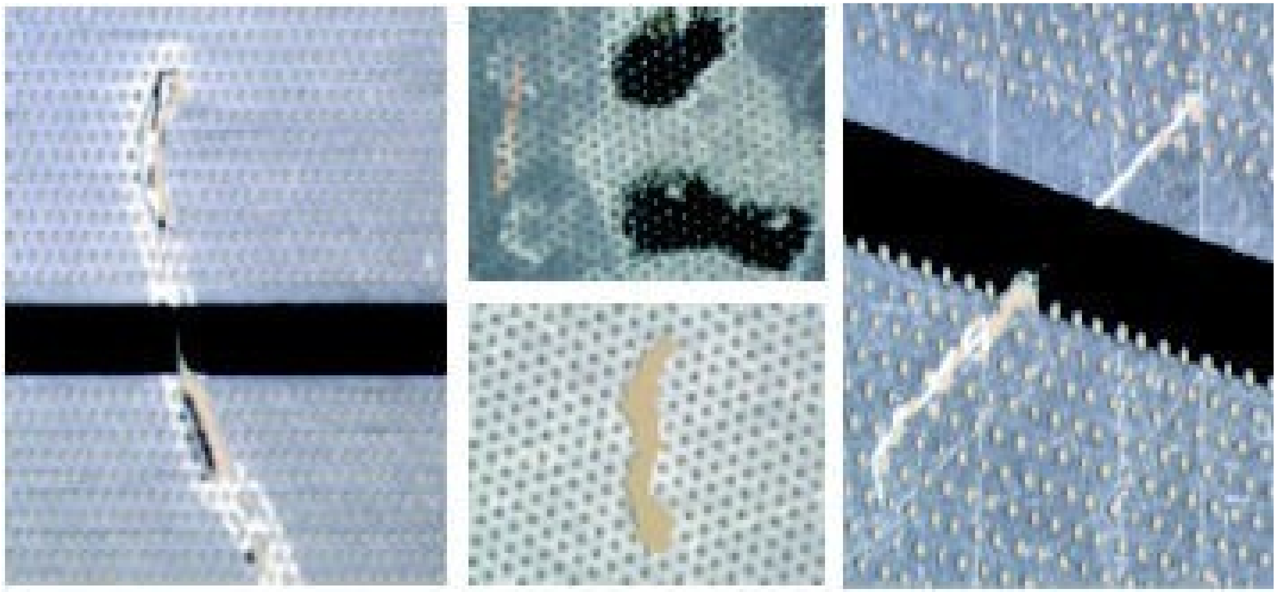




ALICE TPC: World’s Largest GEM-TPC

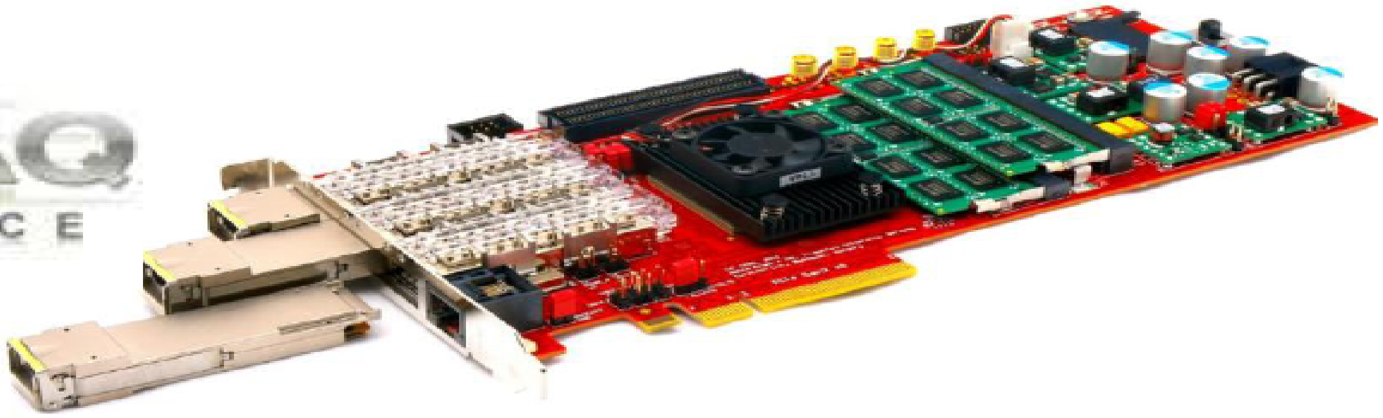
- Measuring the path of the particles with the World’s largest 90m3 Time Projection Chamber





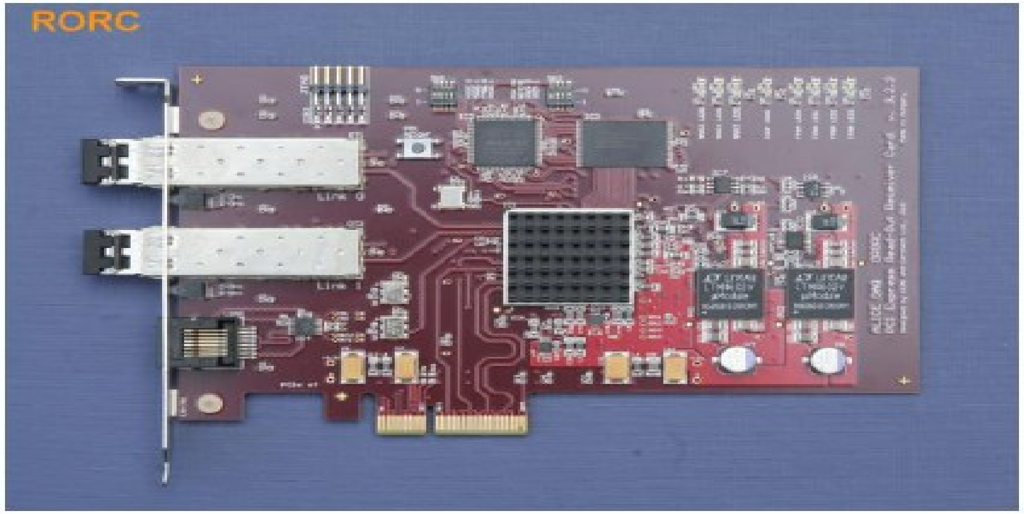
HUNGARIAN CONTRIBUTION TO DATA ACQUISITION (DAQ)

- Major role in the ALICE DAQ system
- Designed and produced the optical links (DDLs) and the computer adapters for these links (D-RORCs) which transmit the data from all the detectors to the DAQ computers. There are currently 500 DDLs running at 2 Gbit/s in use in ALICE.

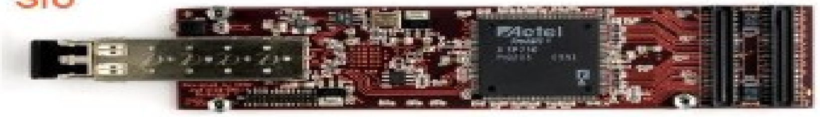


HUNGARIAN CONTRIBUTION TO DATA ACQUISITION

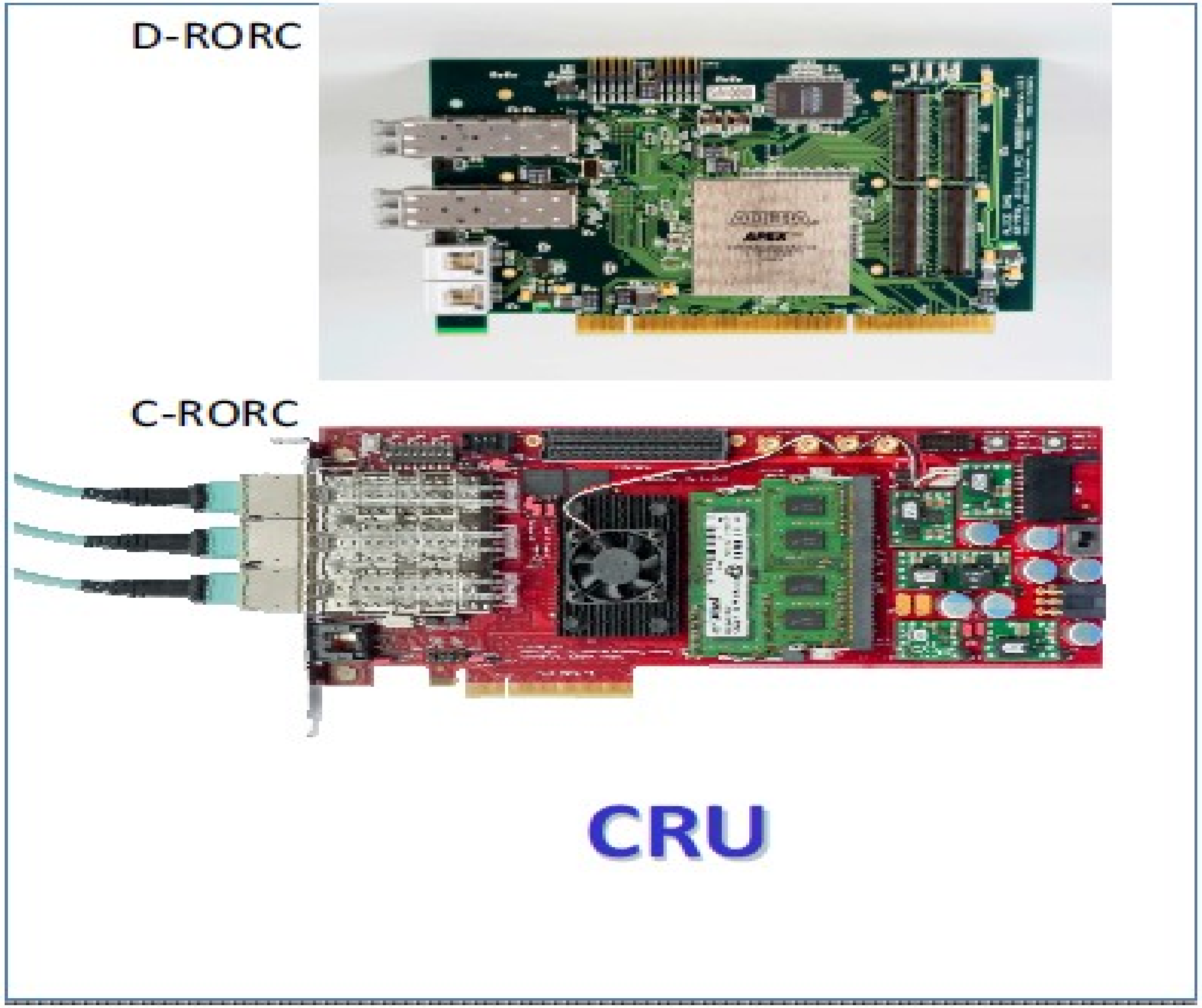
- ✓ Providing a **readout bandwidth of 1 Tbit/s**. They are also used in the reverse direction to configure the electronics of some detectors (e.g. TPC or MCH). The same links are used to transmit the data to the HLT computers.
- ✓ Developed the system drivers used with the DDLs and the DRORCs.
- ✓ Funded the DDLs and part of the D-RORCs.



SIU



ALICE DDL/DAQ: data on the Highway

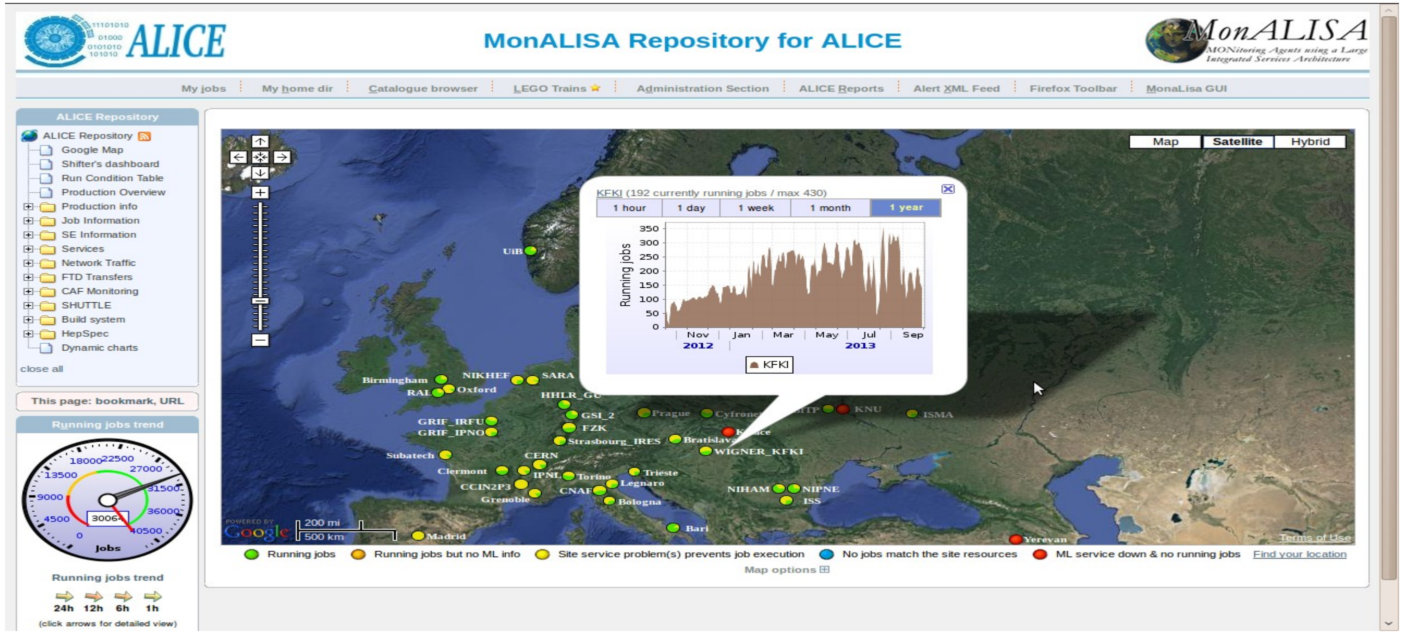


- Standardised detector data links (DDL) as the common interface between the detectors read-out and the DAQ (online system)
- Run1:
- 2.125 Gb/s custom DDL & D-RORC
- Run2:
- 4.25 Gb/s custom DDL2 & C-RORC
- Run3:
- Common Read-out Units (CRUs) as common detector, an trigger, and control interface
- 10..40 Gb/s commercial DDL3 (10 GbE or PCI Express over fiber)

GRID – ALICE Tier-2

High Performance Computing: Wigner GPU Lab

- HR: 1-2 technicians
- 1000 cores shared between ALICE & CMS
- Storage Element 740 TB
- Local CAF for R&D
- GPU Lab &
- Other special machine

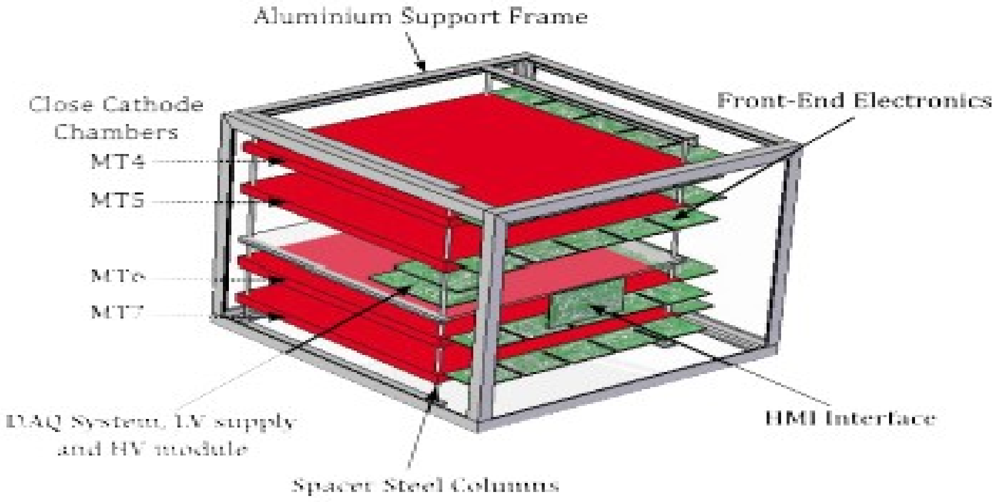


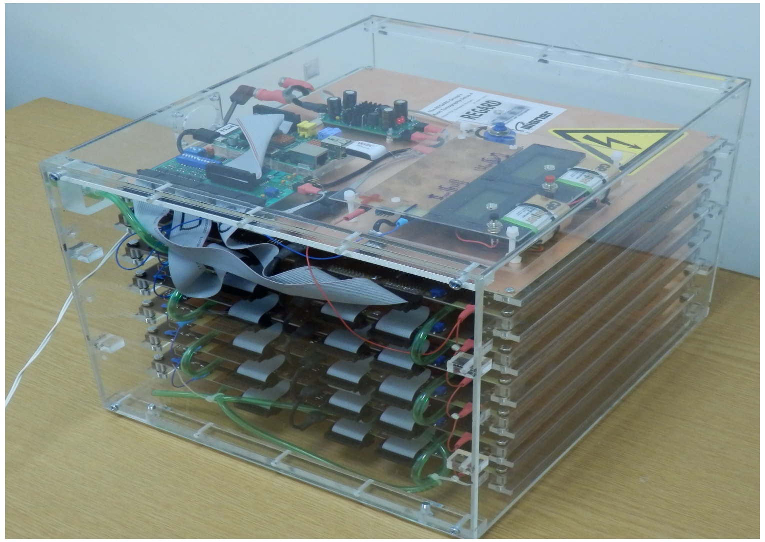
Collaborations in Applied Physics

Cosmic Muon Tomography

Mountomograph

- Size: 50x50x50 cm3
- Sensitive area: about a A4 page
- Resolution < 10 mrad
- Mass: 10-13 kg
- Power consumption: < 5W
- Gas Ar+CO2 1l/hour
- For sale 3000 EUR+TAX+shipment

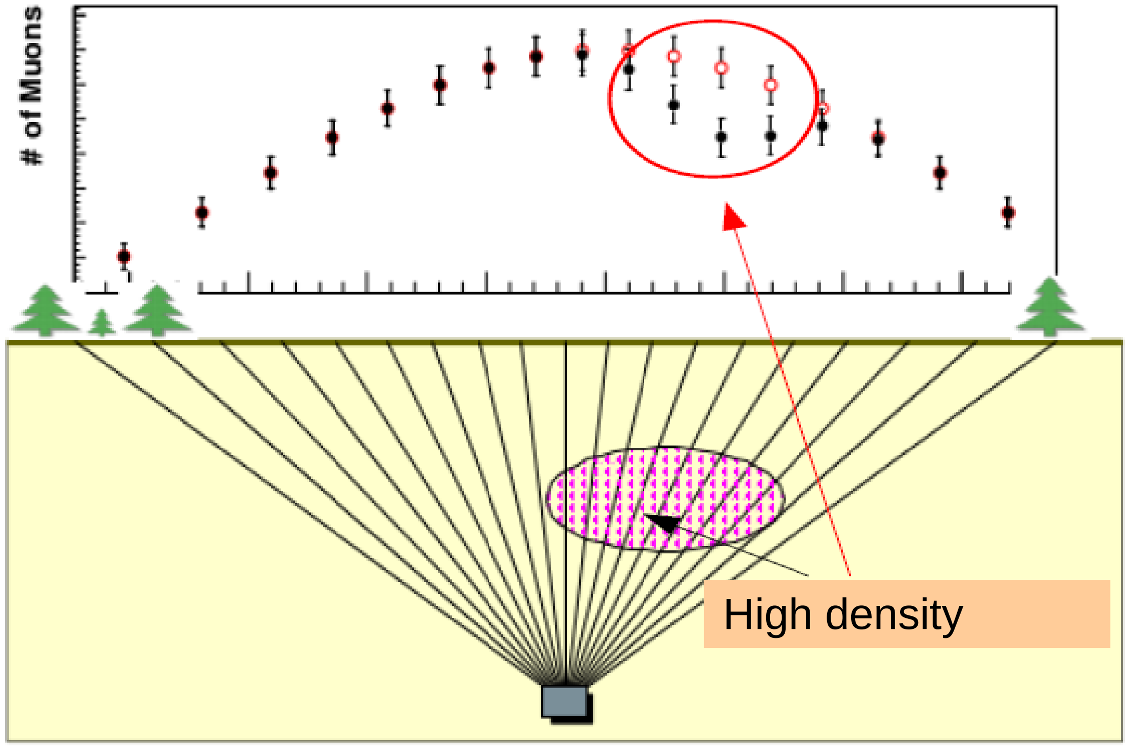




Cosmic Muon Tomography

Mountomograph – the idea

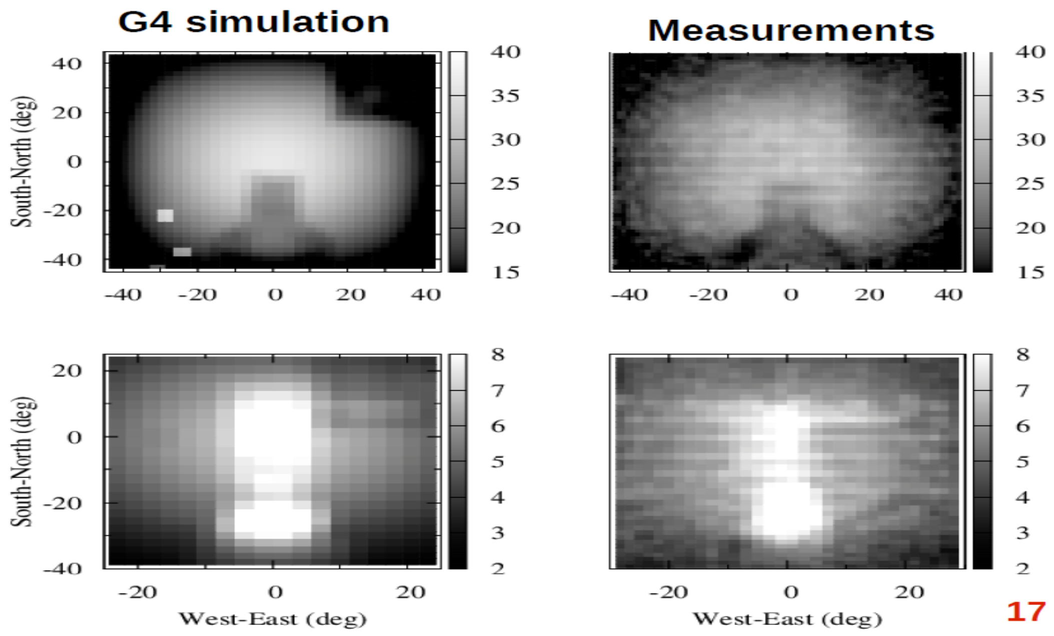
- Cosmic muon angular distribution & flux is well known
- Underground measurements can be done to measure large-scale inhomogenities
- It can be used to explore undergound structures: caves, pyramids, pipes, mines, volcanoes..

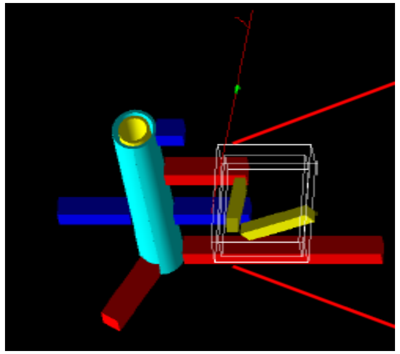


Cosmic Muon Tomography

Mountomograph references

- HZDR Dresden, Germany
  Underground Laboratory background
- Saud Arab Emirates
  Archeology & mine technology
- University of Tokyo, Japan
  Volcano Scanning for eruption research
- Hungary
  Speleology (cave research)
  Civil Engineering
  Homeland Security





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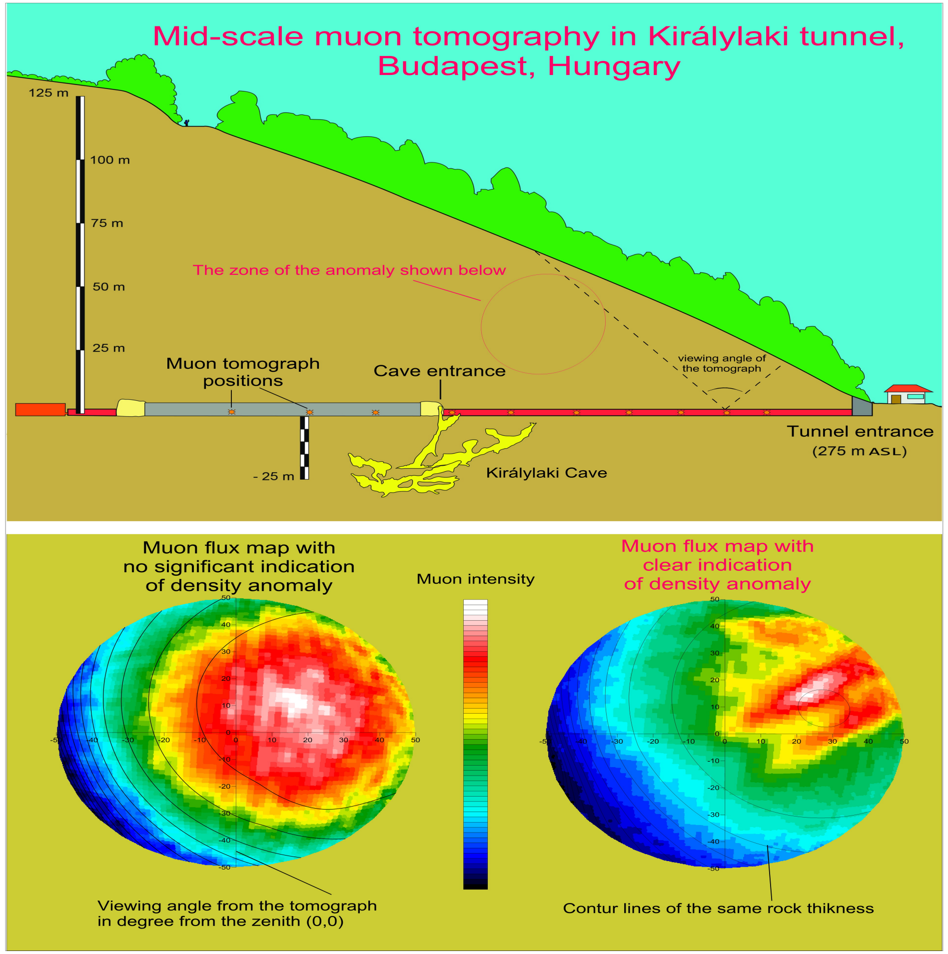


Hadron therapy: particle physics against cancer...

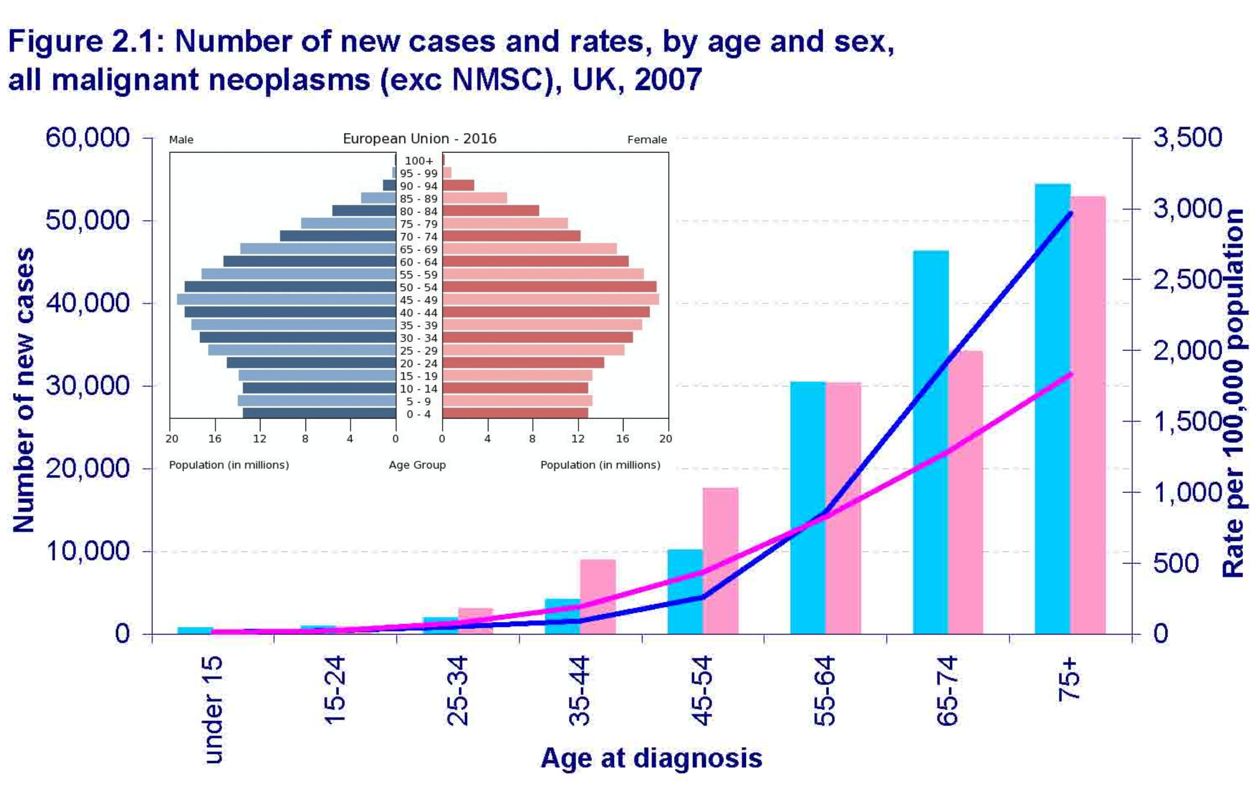
Radiotherapy is an important weapon in the battle against cancer

Contributions to successful treatment of cancer

45-50% surgery

40-50% radiotherapy

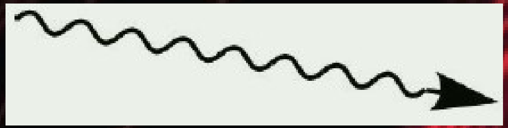
10-15% chemotherapy



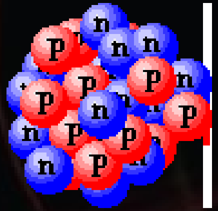
Hadron therapy: particle physics against cancer...

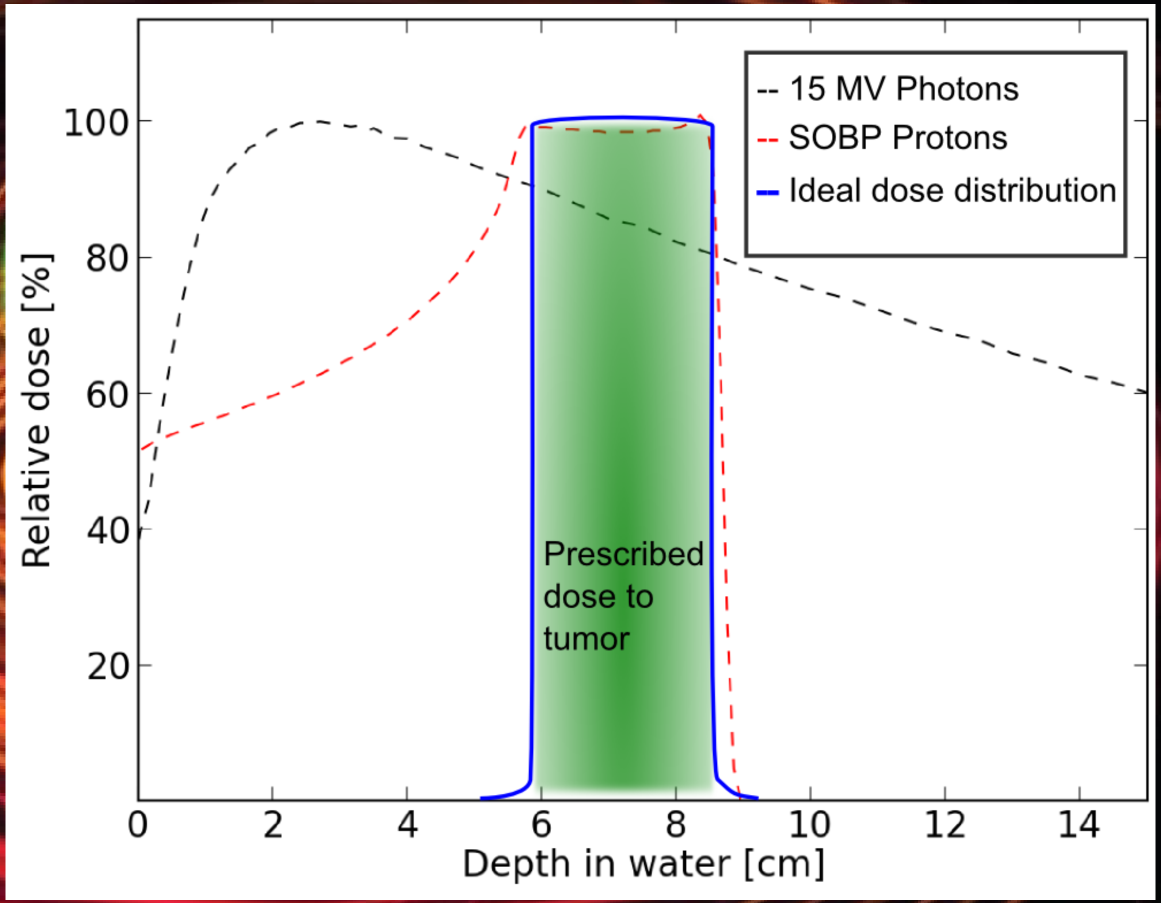
The goal of radiation therapy is to irradiate the tumor with the prescribed dose and minimize the dose to healthy tissue

Photons (electromagnetic):



Hadrons (proton, nuclei):

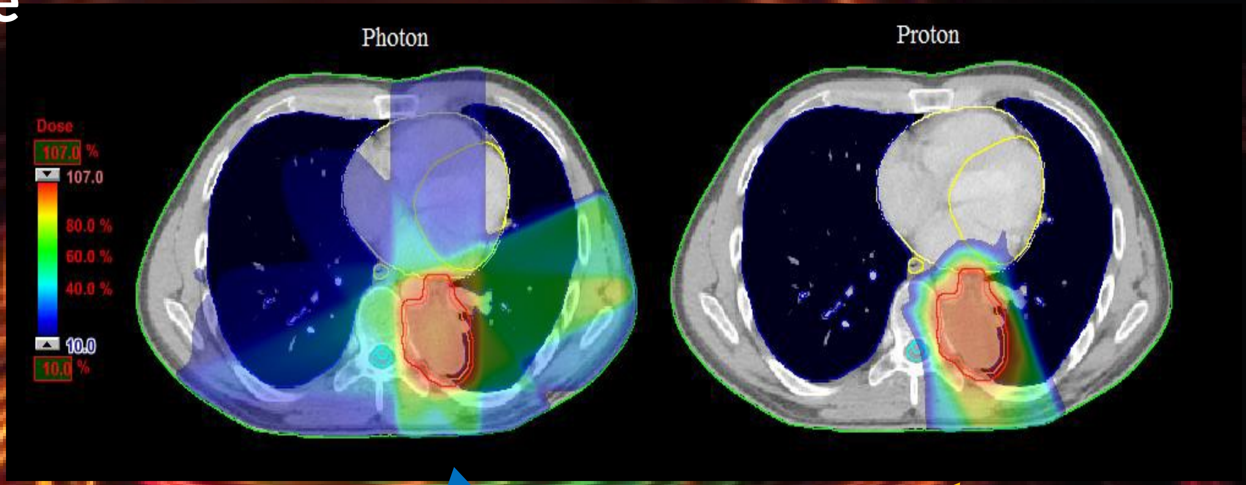




Hadron therapy: particle physics against cancer...

The goal of radiation therapy is to irradiate the tumor with the prescribed dose and minimize the dose to healthy tissue

Figur fra Engeseth, GM (Haukeland)



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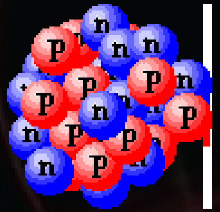
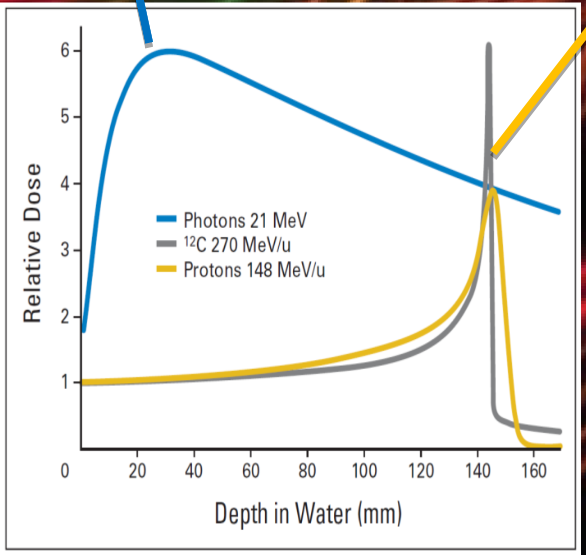
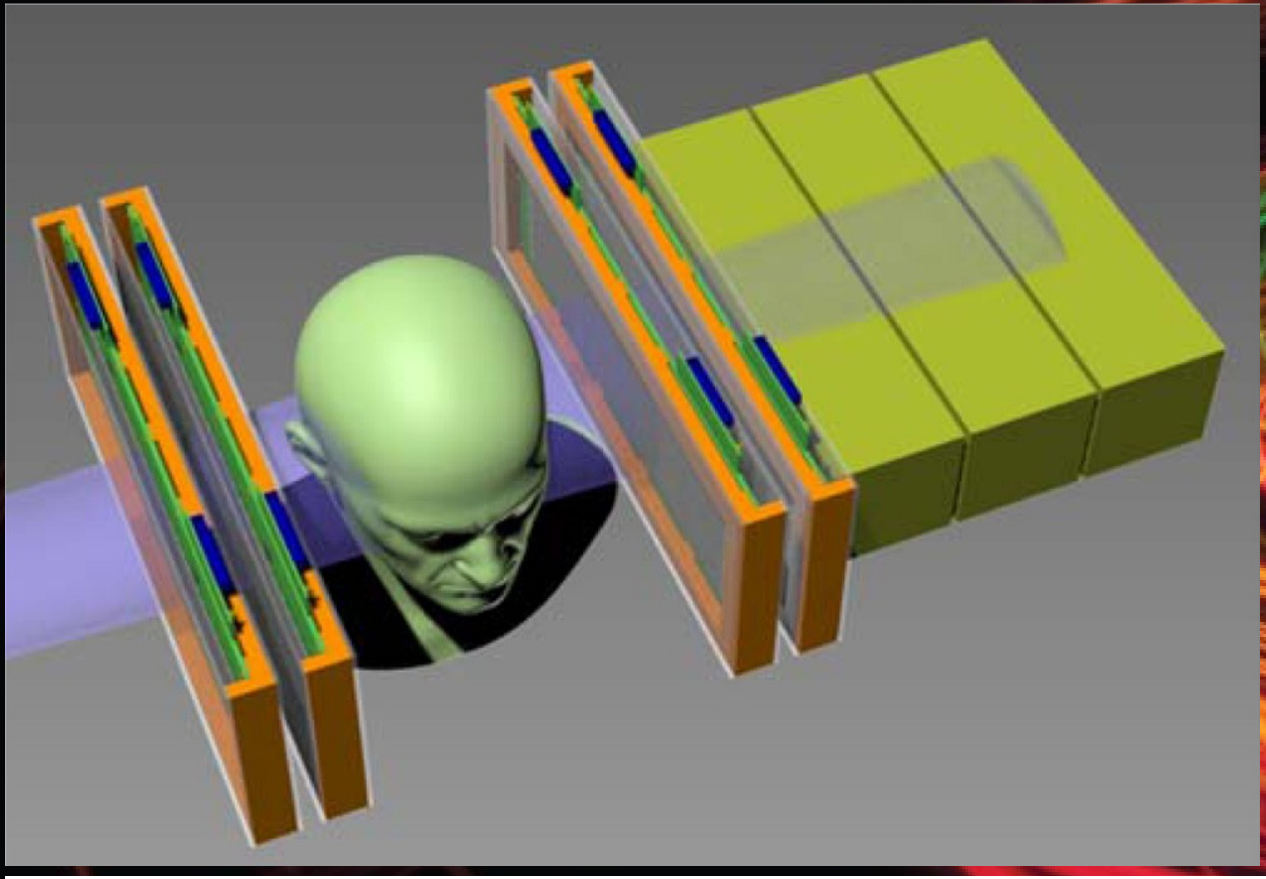




pCT project with University of Bergen



H.F.-W. Sadrozinski / Nuclear Instruments and Methods in Physics Research A 732 (2013) 34–39

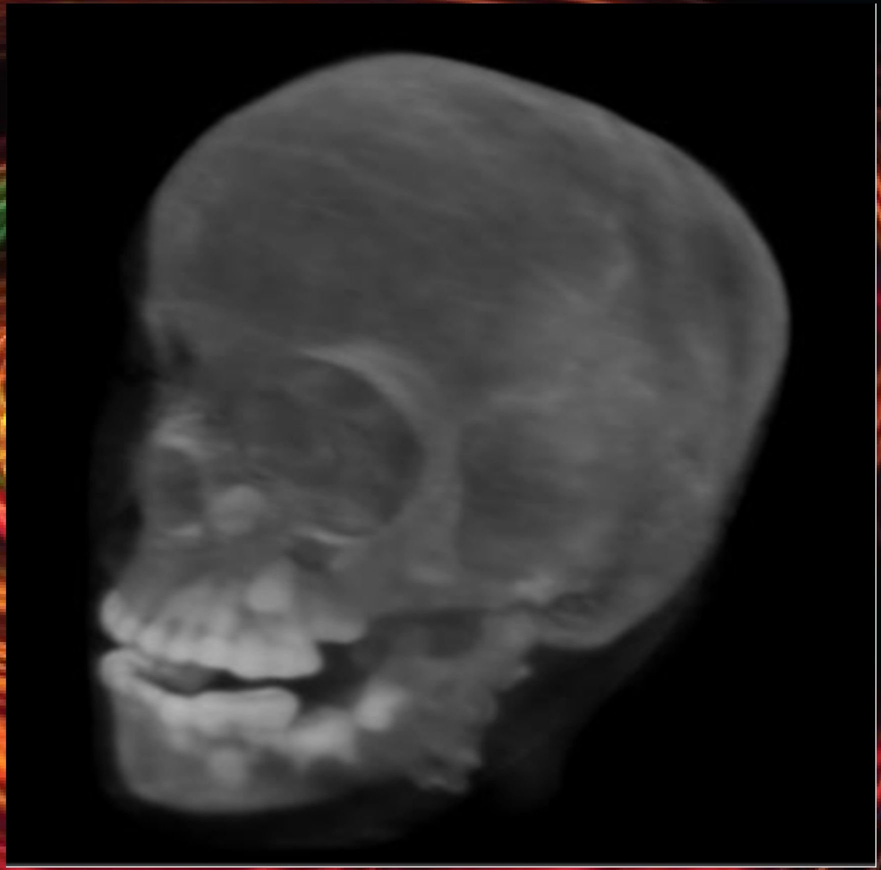
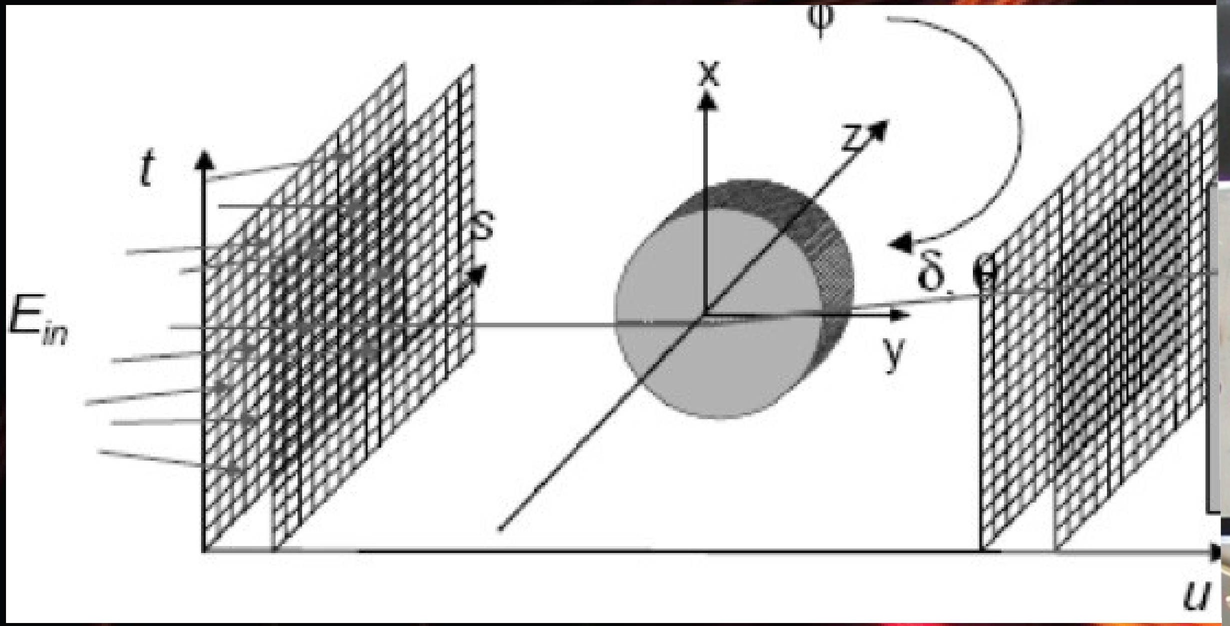
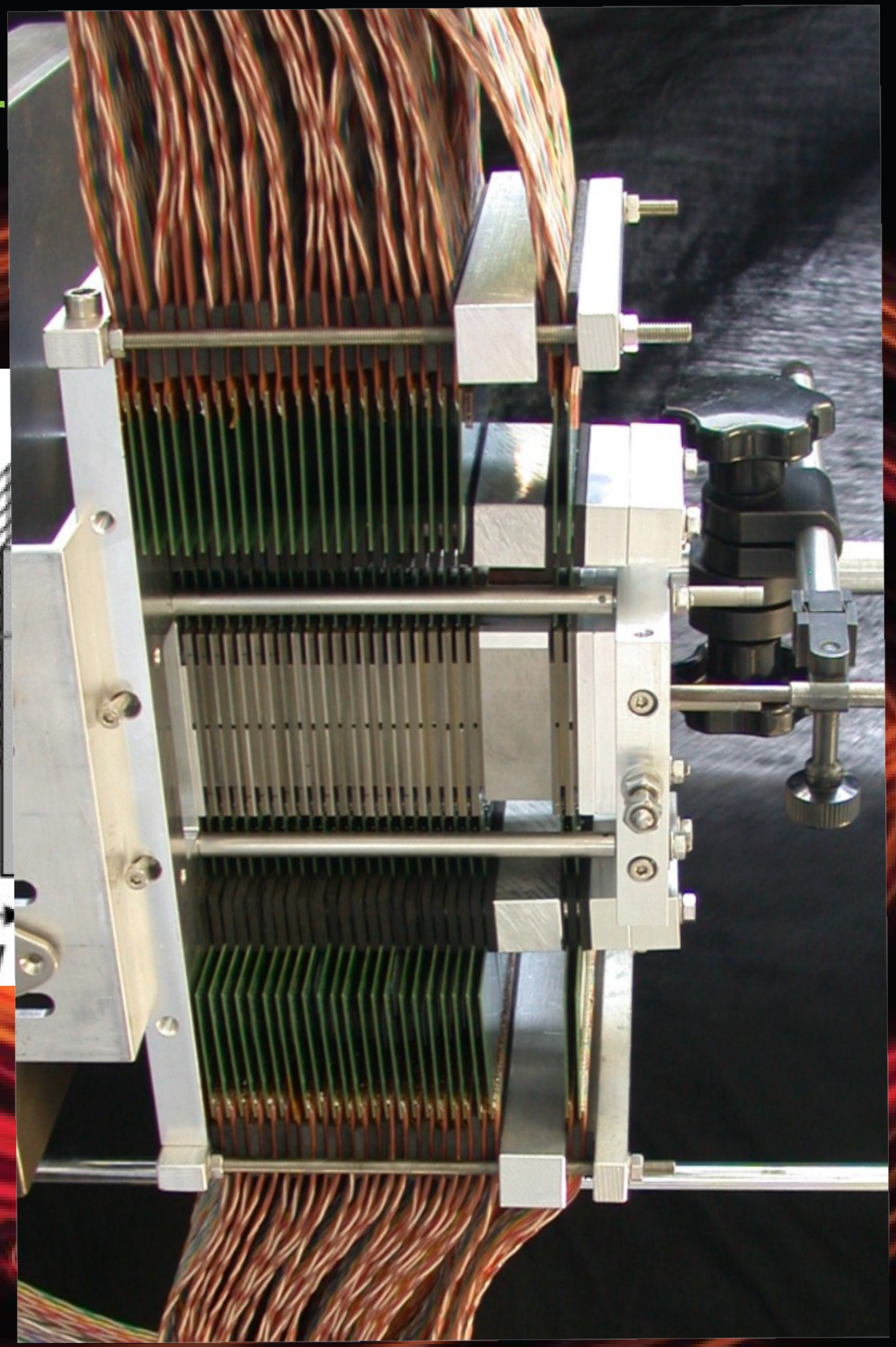


Fig. 14. 3D rendering of the pCT-reconstructed RSP map of a pediatric anthropomorphic head phantom.

V.A. Bashkirov et al. / Nuclear Instruments and Methods in Physics Research A 809 (2016) 120–129

pCT project with University of Ber





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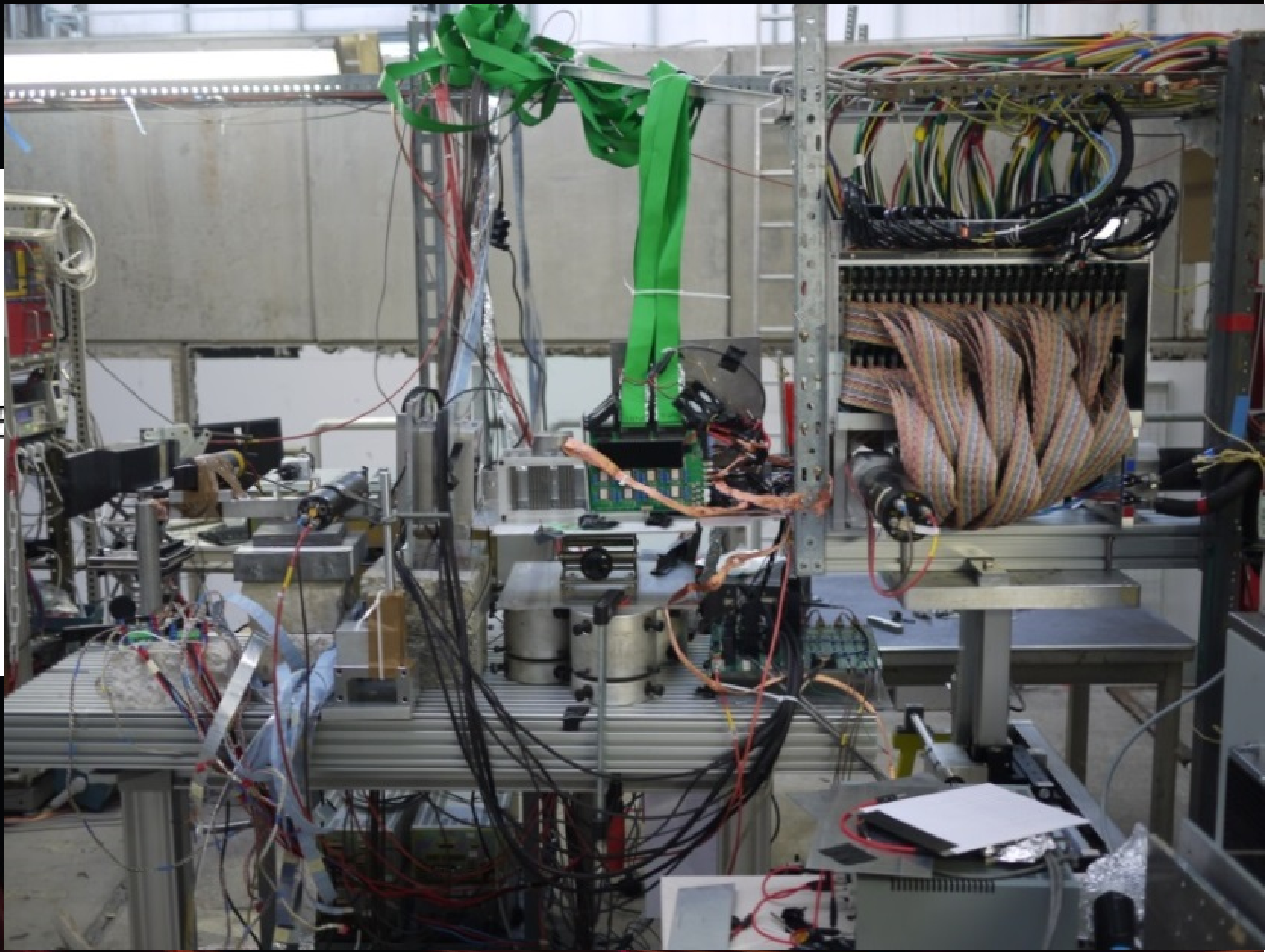
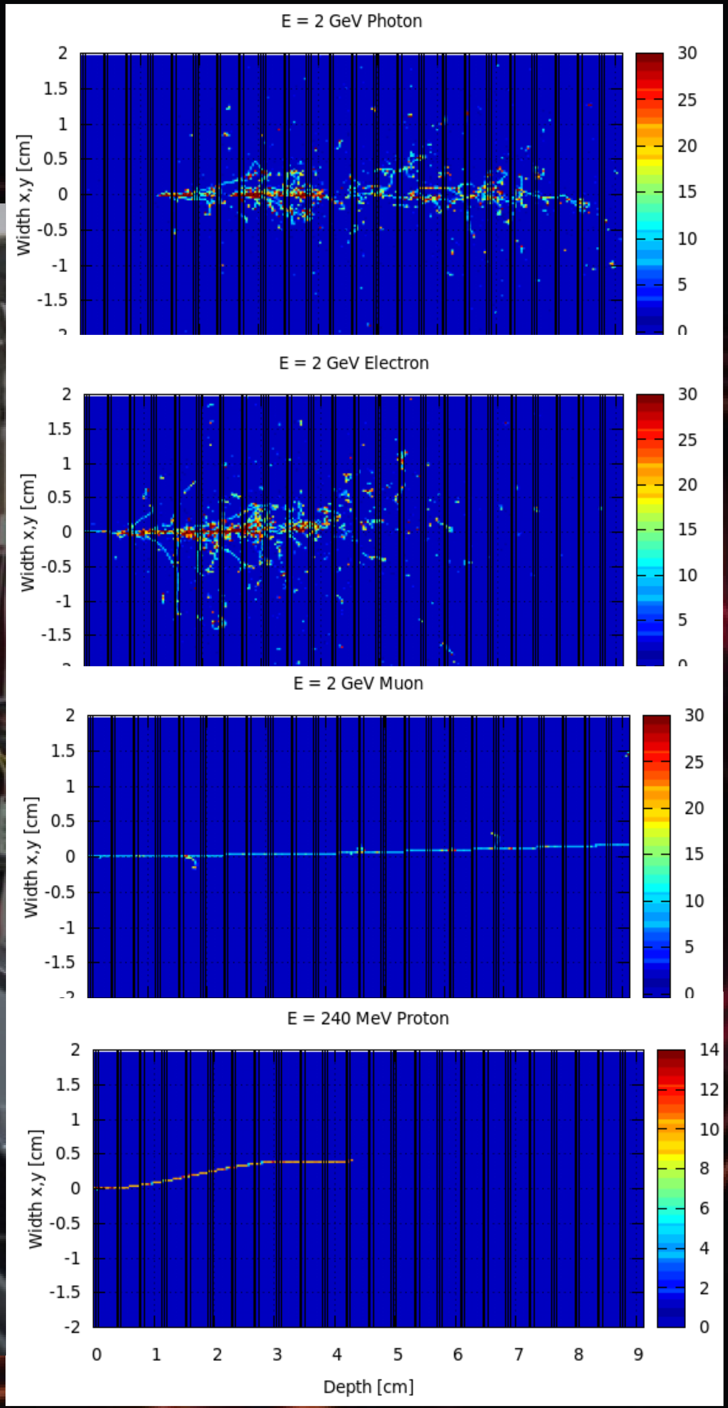




Computing: Wigner GPU Laboratory

Software R&D for parallel computing

Wigner GPU Laboratory

- gpu.wigner.mta.hu
- GPU Day – Schools & Workshops
- Support of projects
- Academy: WDC, CERN Openlab
- Partners: Lombiq,KHRONOS
- ColSpotting: CERN IT as USER(!)
- 2 years of running:
  - Fellowships (1-2 month)
  - 10 IF papers
  - 3-5 ongoing projects

We Offer

Development environment for GPU codes

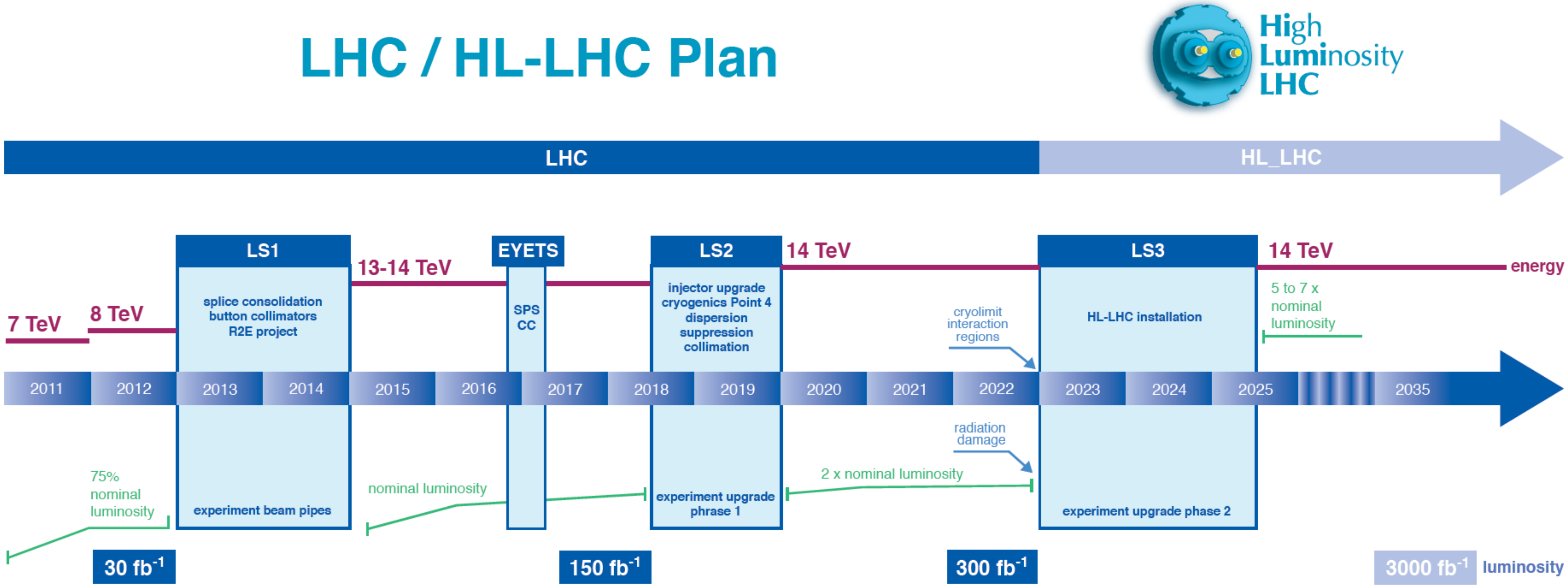
The machines of the GPU Lab are built to be a testbed for experimenting with the different GPU technologies and to test algorithms utilizing multiple cards. There are configurations hosting NVIDIA cards with CUDA support and OpenCL capable devices in the form of AMD GPUs and Intel Xeon Phis

Developer assistance and consulting

The associates of the GPU Lab are keen to help in understanding the architecture of CPU and GPU hardware and answer the questions arising in programming and API usage.

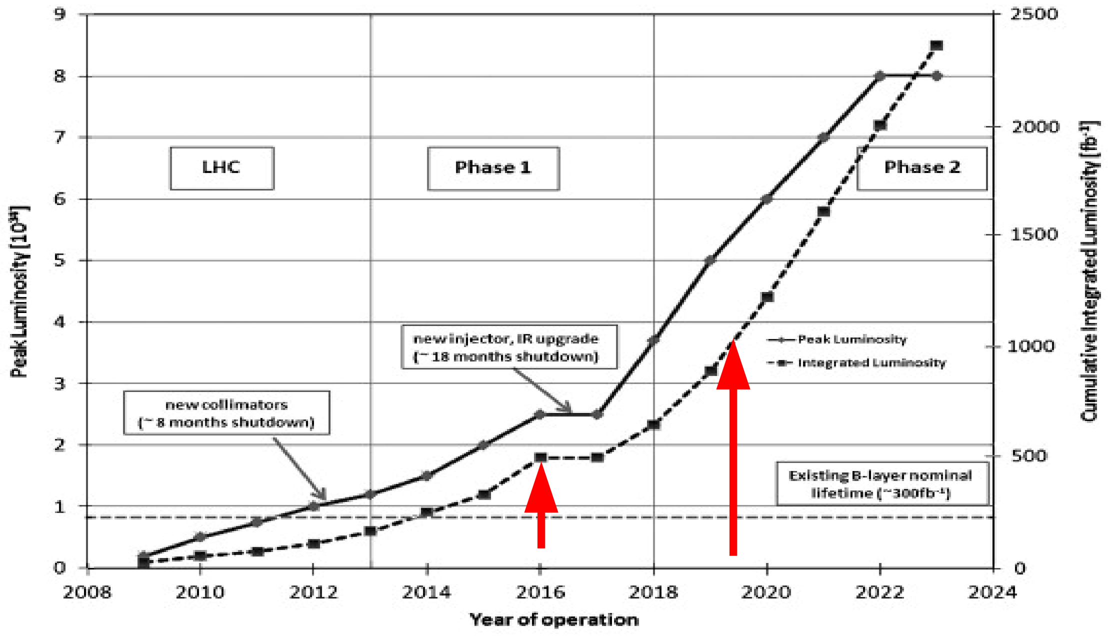
HI data from the Large Hadron Collider

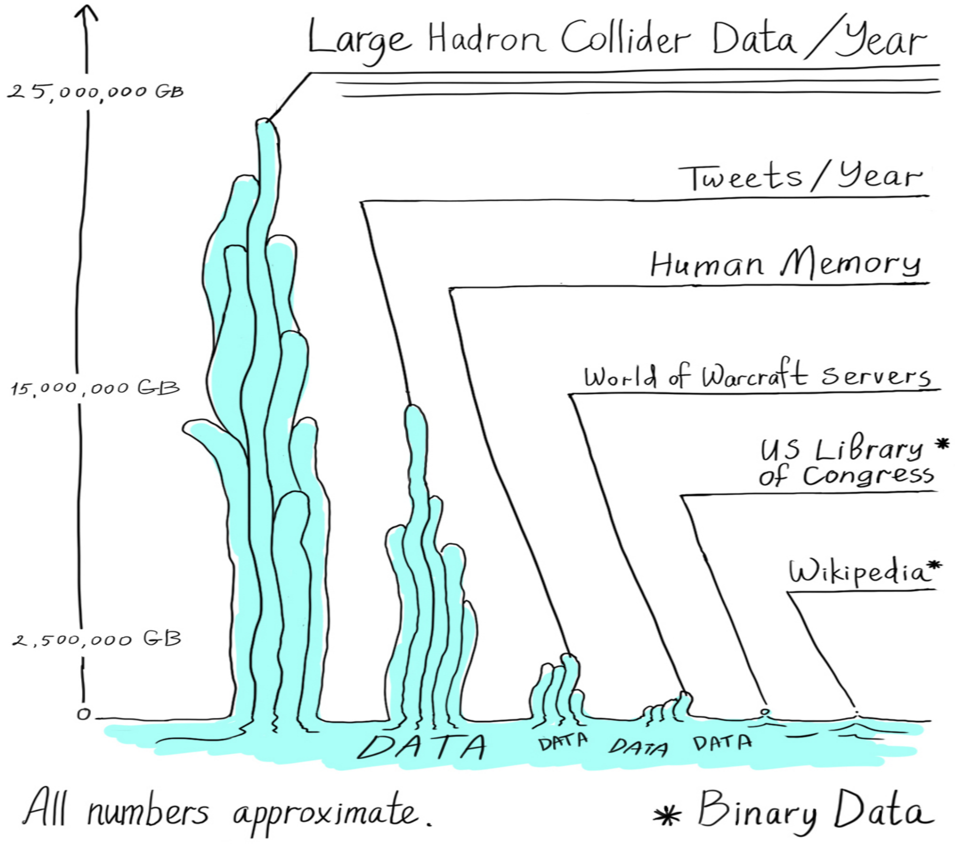
- LHC upgrades & theories required more and faster HI simulations



HI data from the Large Hadron Collider

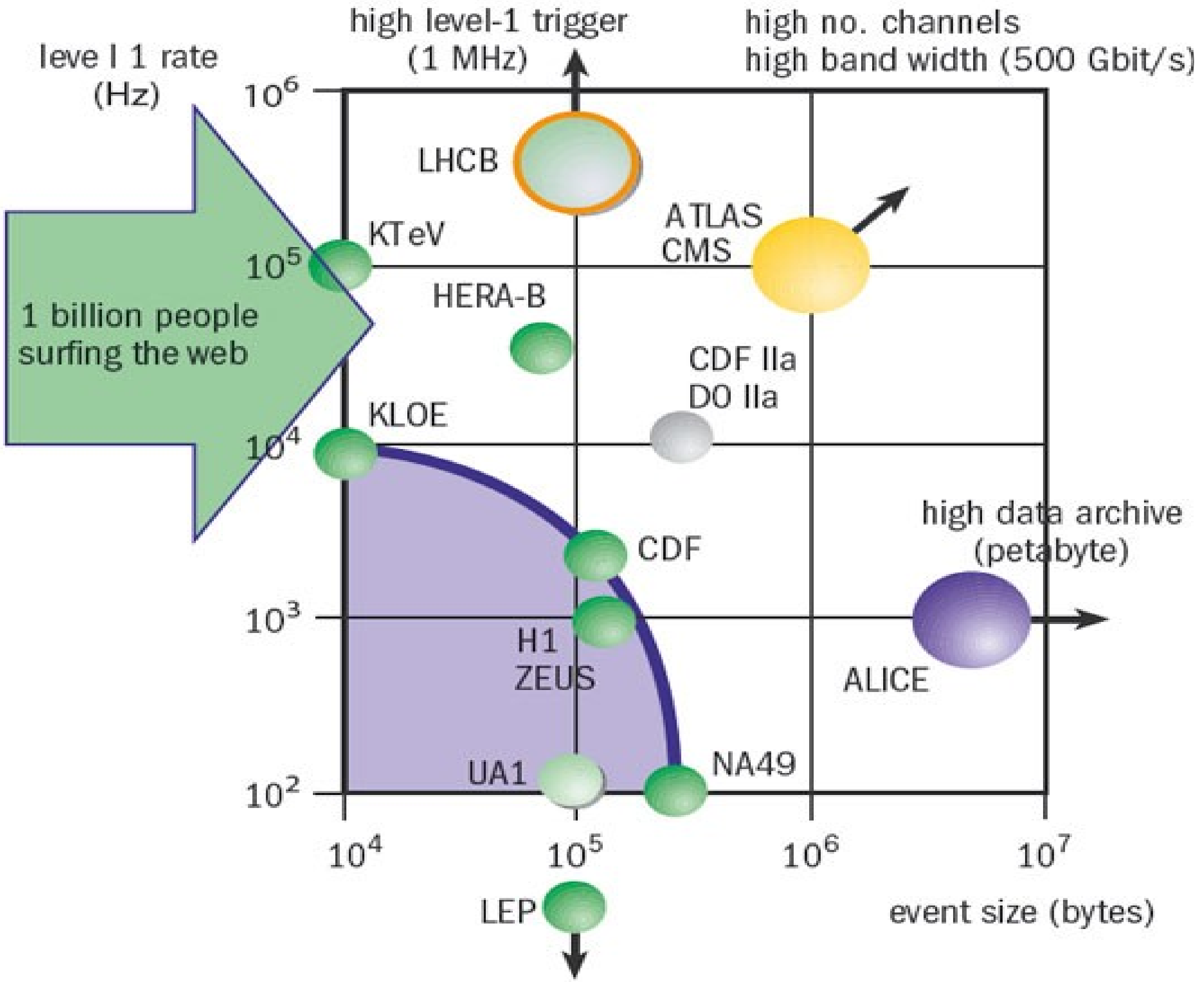
- WLCG – Worldwide LHC Computing GRID:
  - LHC made 15-20 PB data per year
  - ...and now before HL-LHC 2PB/day





More data: motivation for fast computing at CERN

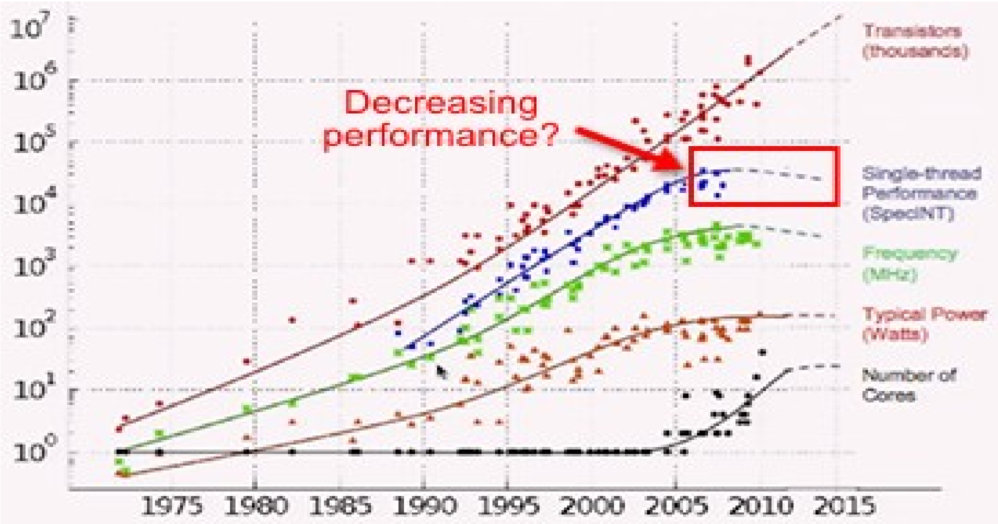
- Ideal: amount of simulated data ≈ real data
  - Number of events at LHC: $\mathcal{O}(10^8)$ / s
  - Necessary time for Monte Carlo with ALICE geometry: $3.8\ ms/track$
- Necessary time to simulate 1 s of ALICE data: $\mathcal{O}(days)$



Fast computing = parallel computing

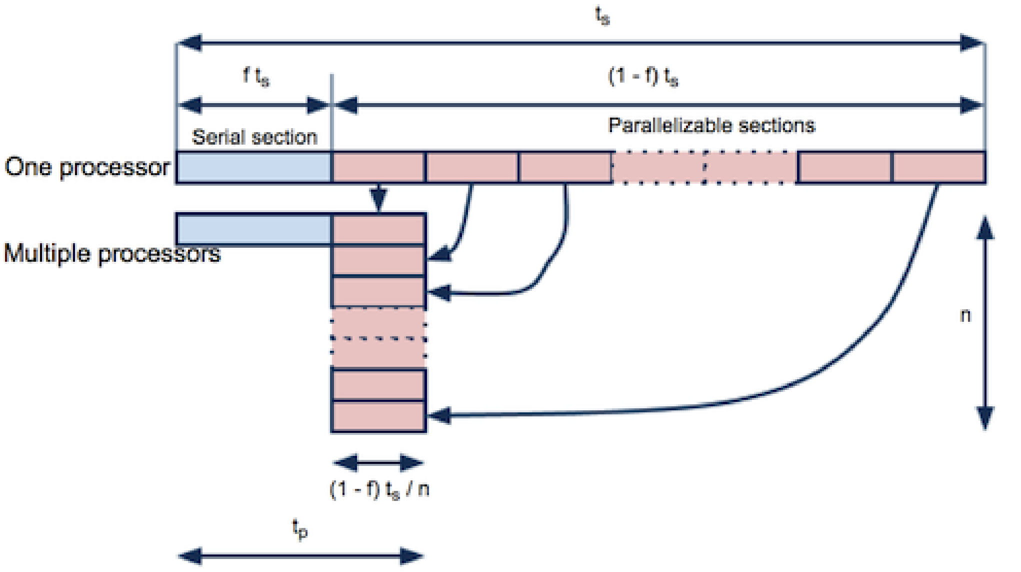
- Moore's law:

Every 2nd year the number of transistors (integrated circuits) are doubled in computing hardwares.



- Amdalh's law:

The theoretical speedup is given by the portion of parallelizable program, p, & number of processors, N, is:



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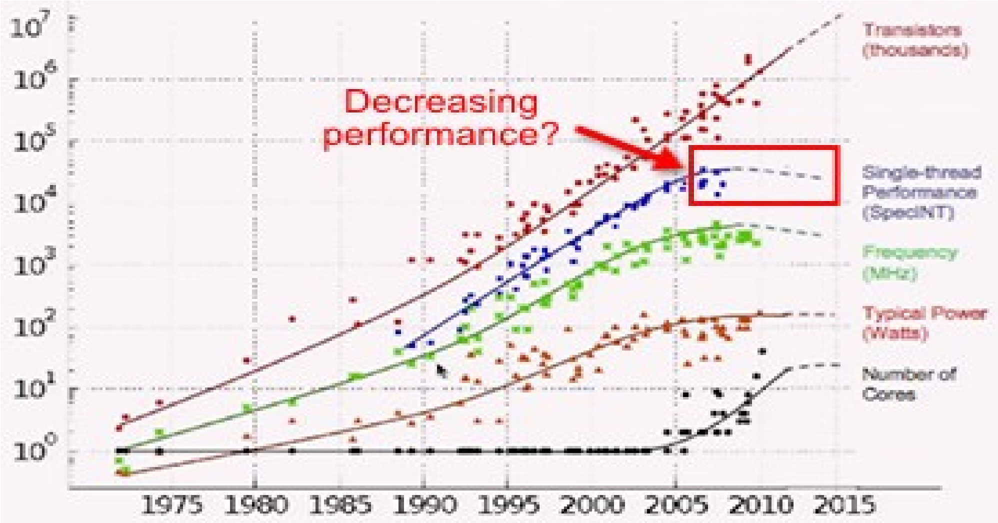


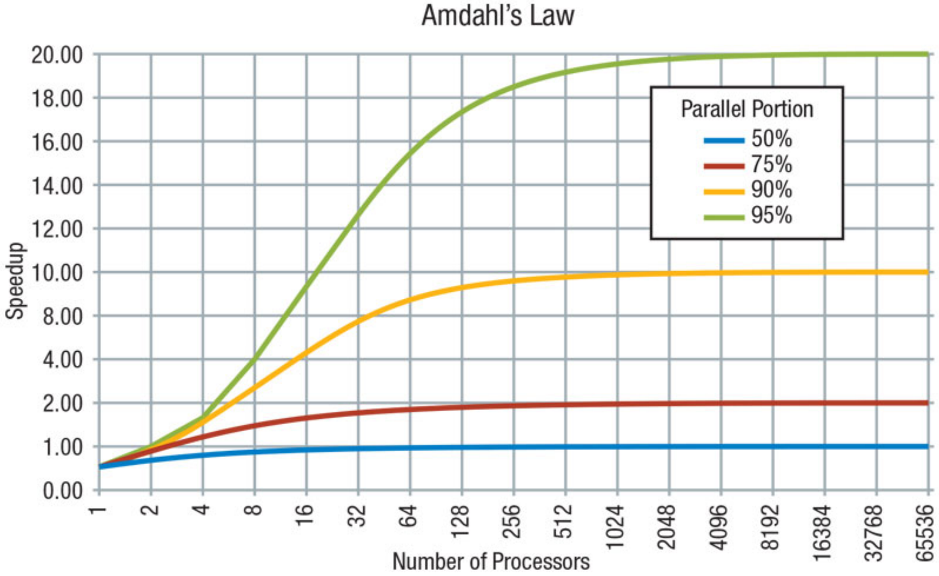
- Amdalh's law:

The theoretical speedup is given by the portion of parallelizable program, p, & number of processors, N, is:

$$\text{Speedup}(N) = \frac{1}{(1-P)+\frac{P}{N}}$$

Serial part of job = 1 (100%) - Parallel part

Parallel part is divided up by N workers



The HIJING++

HIJING(Heavy-Ion Jet INteraction Generator)

易經

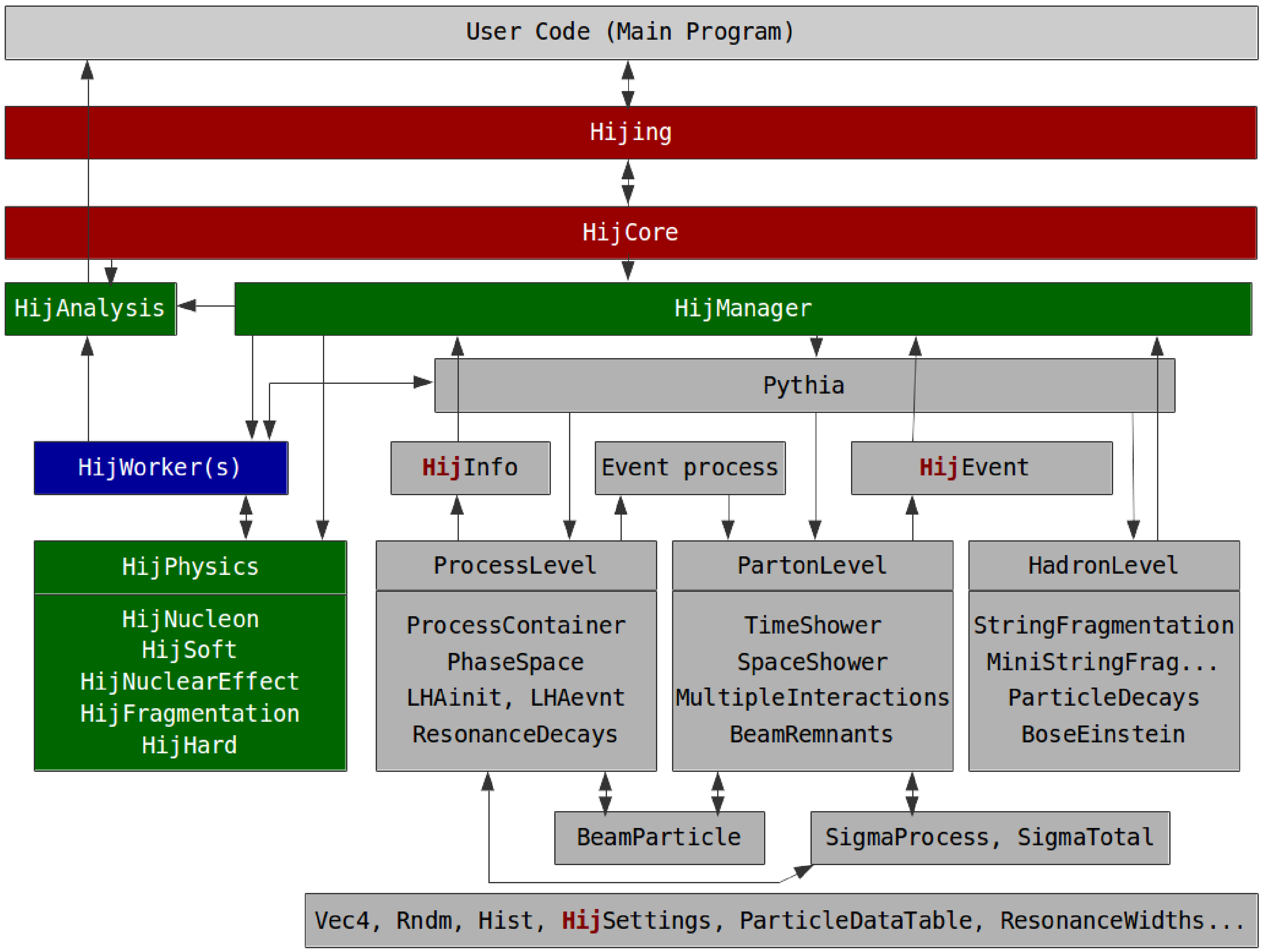
Bagua (eight simbols)

fundamental principles of reality

adjoint representation 8 of *SU(3)*

Program Structure

- Pythia8 namespace containers
- Structure similarities
- Actual program flow is more complicated
- New: HijManager



Join us

THOR EU COST Action CA15213

- Theory of Hot Matter and Relativistic Heavy Ion Collisions
- http://thor-cost.eu

PHAROS EU COST Action CA16214

- The multi-messenger physics and astrophysics of neutron stars

Wigner GPU Laboratory

- Highly-parallel computing techniques
- http://gpu.wigner.mta.hu

Email contact: barnafoldi.gergely@wigner.mta.hu

PHAROS
THE MULTI-MESSENGER PHYSICS AND ASTROPHYSICS OF NEUTRON STARS