Detectors and Novel IT Solutions for the FCC

Gergely Gábor Barnaföldi
FCC co-representative
group leader (HI, ALICE, WSCLAB)
15th May 2024

HUN-REN Wigner Research Centre for Physics

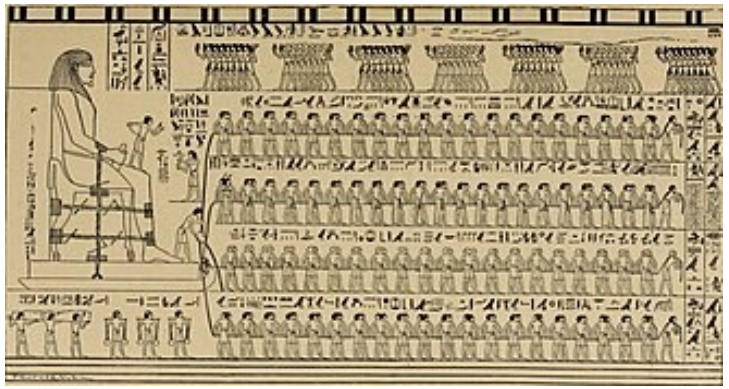
Research.
Innovation.
Impact.

Any question related to FCC?

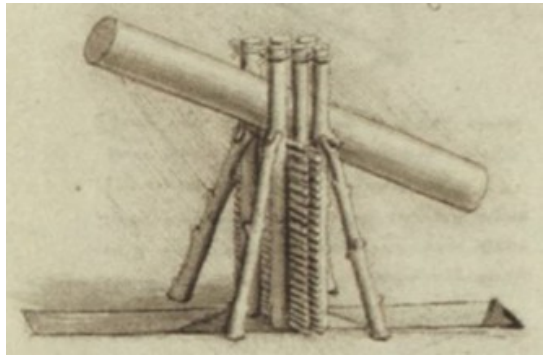
HUN REN | wigner

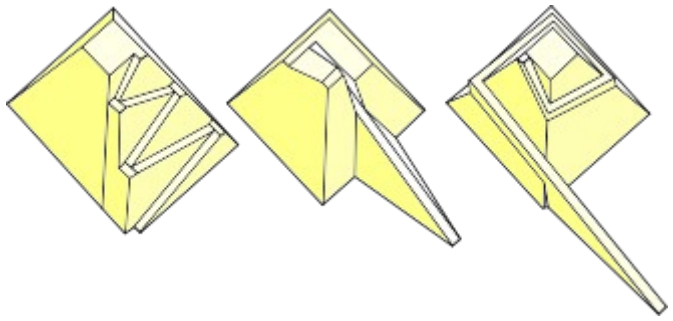
Motivation

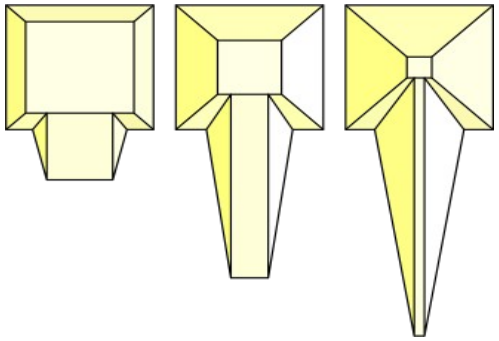
- Why and who built the pyramids? → Experts (not slaves) about O(10k)



- What technologies were used? → Were are these now?





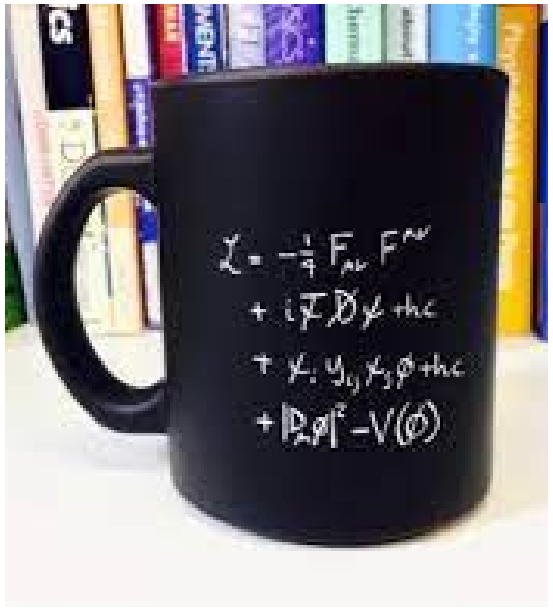


Question #1?

Why?

What will answer the FCC?

SM



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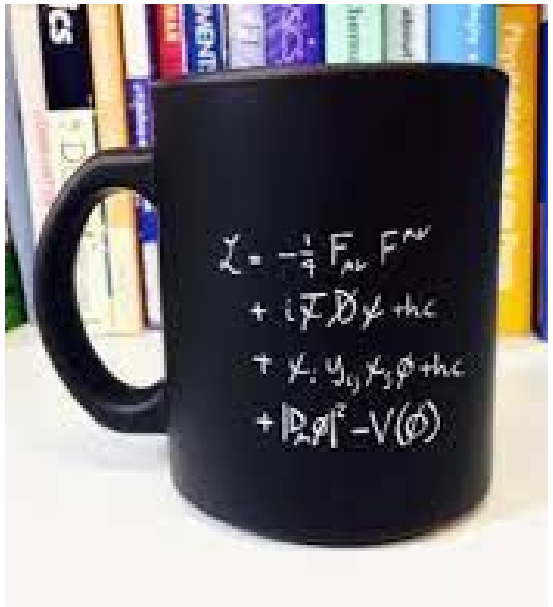
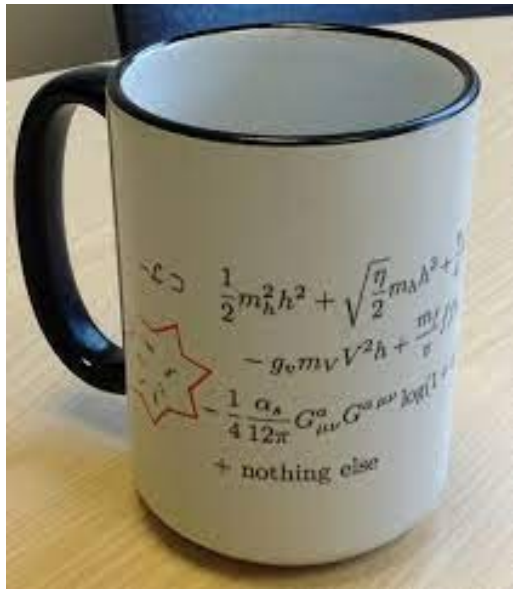


BSM



What will answer the FCC?

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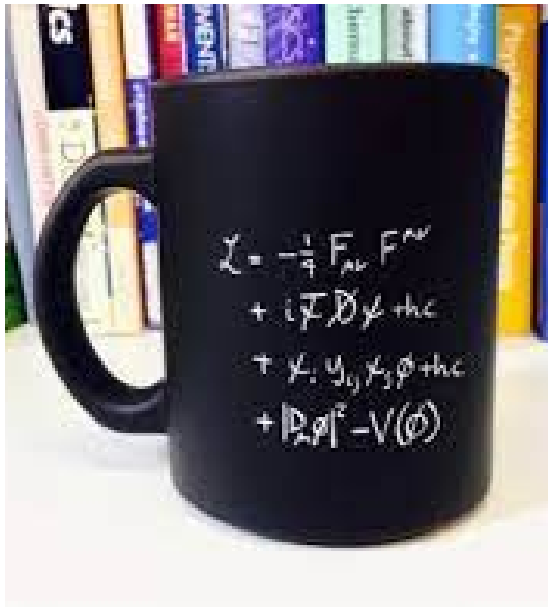

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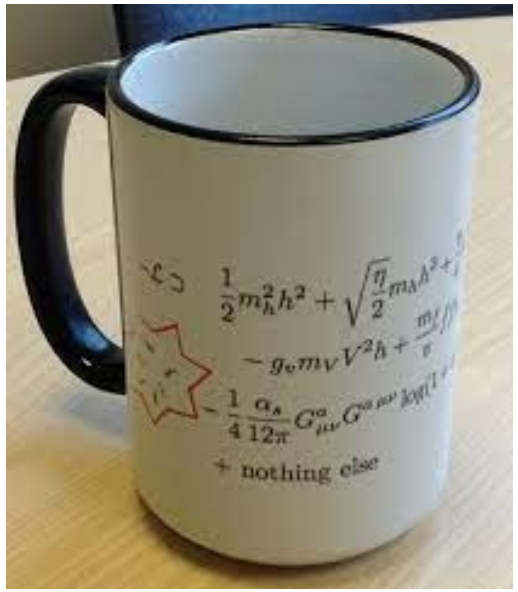
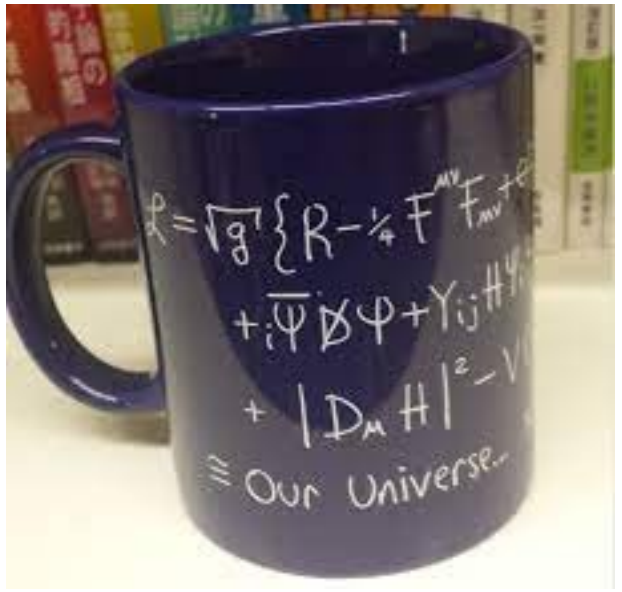


DM



What will answer the FCC?

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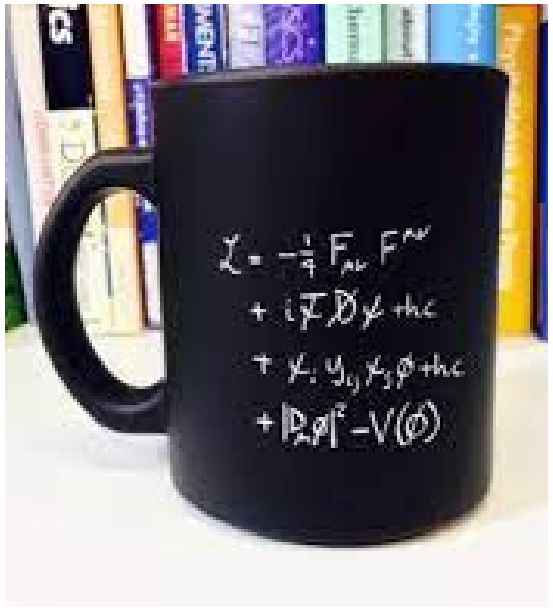

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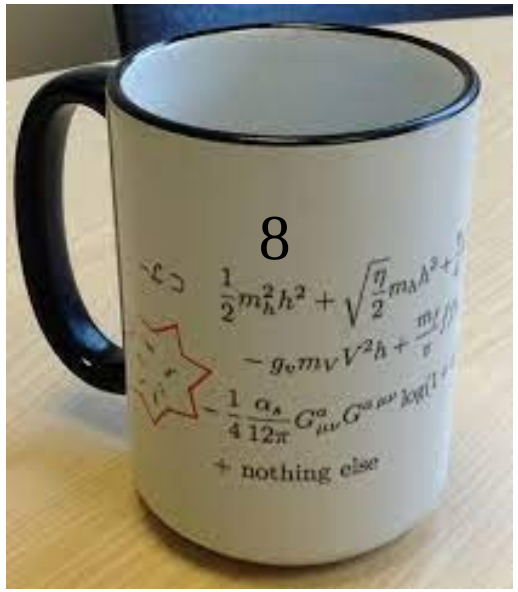

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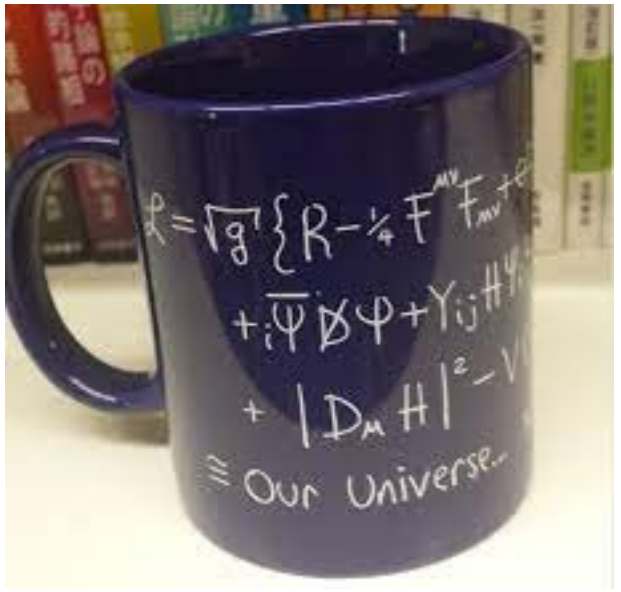

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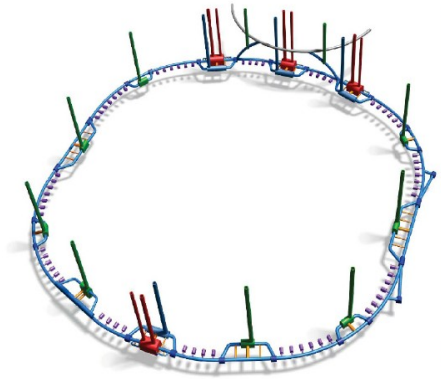
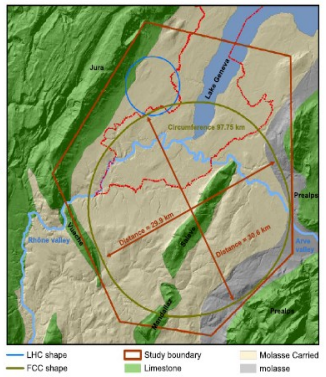
Question #2&#3?

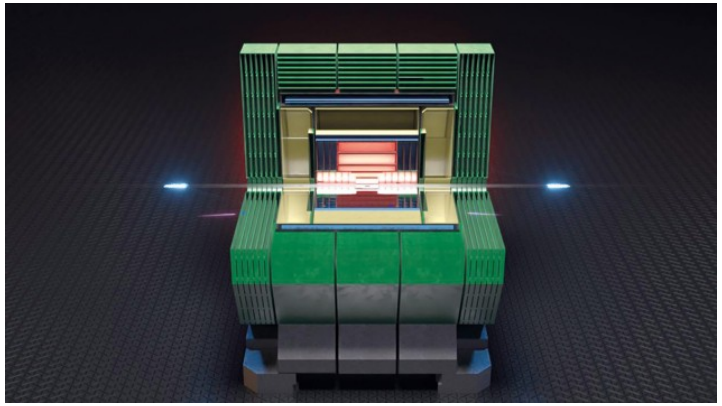
Where & Which?

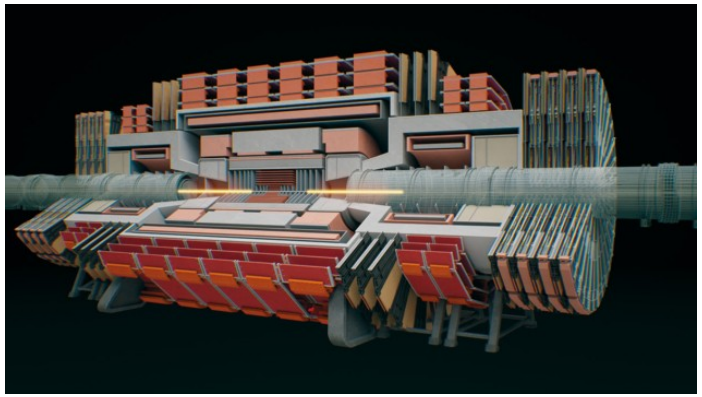
Two competing proposal...

- Future Circular Collider (FCC)

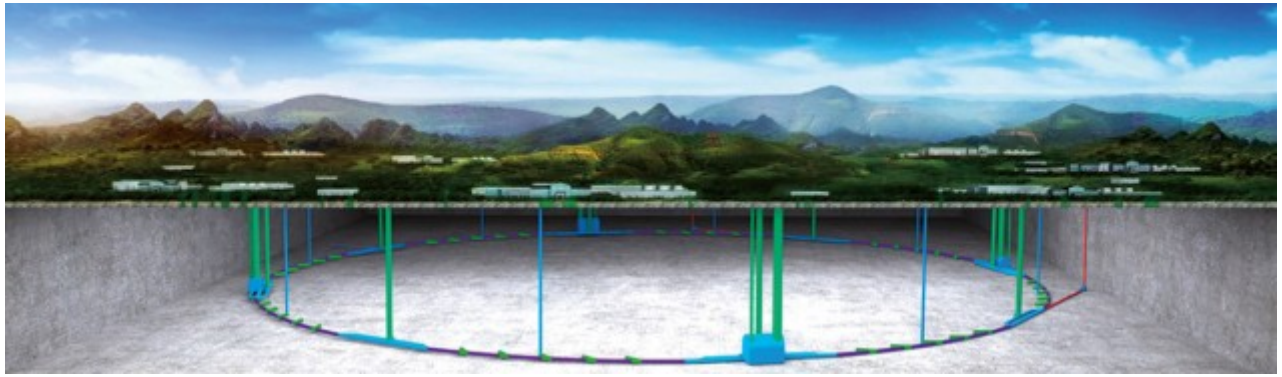


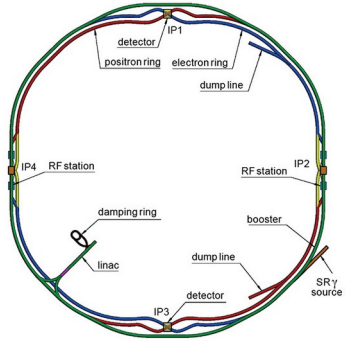


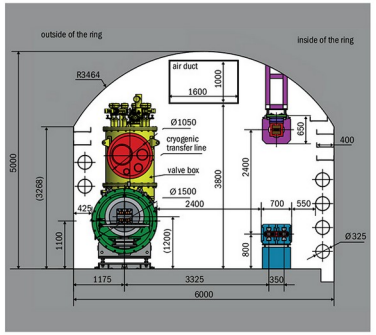




- China Electron Positron Collider (CPEC)



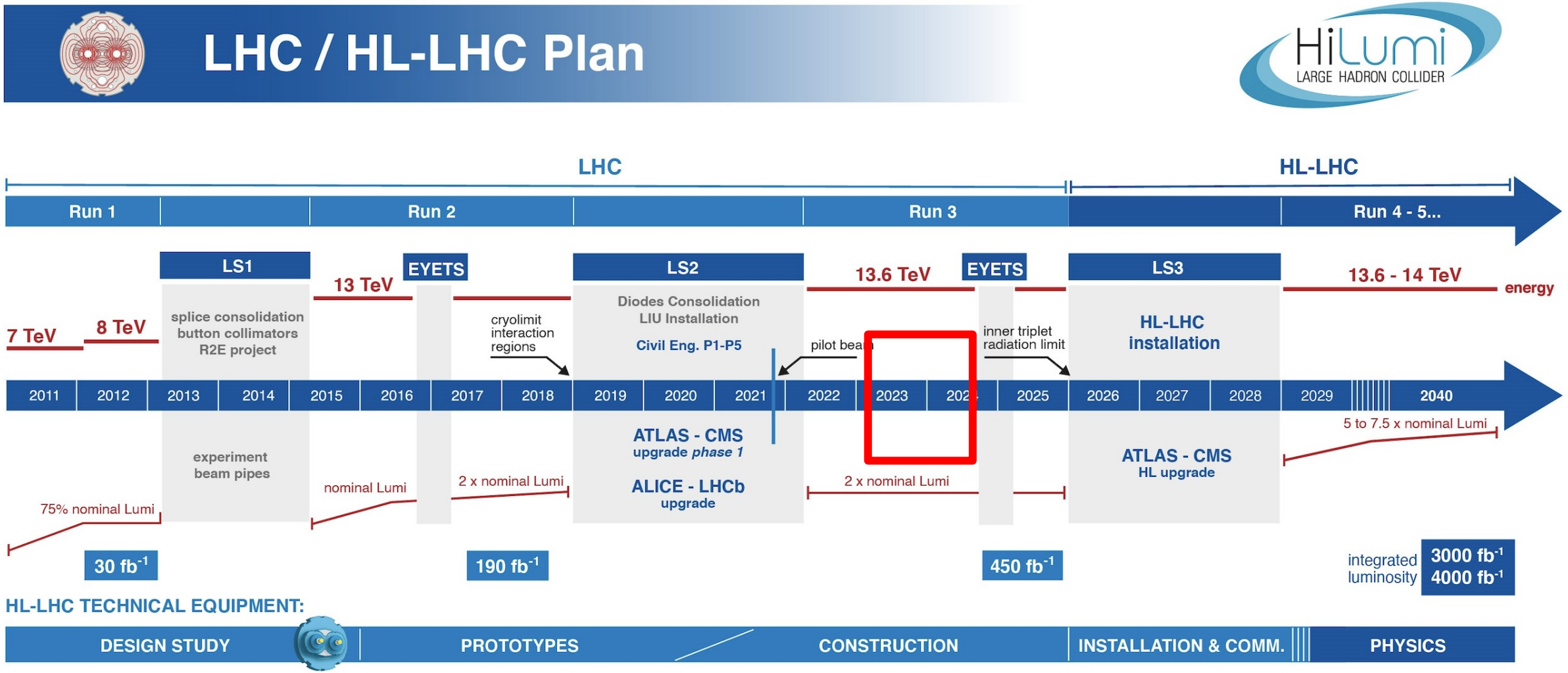




Question #4?

When?

Recent Circular Collider Timeline



Recent Circular Collider Timeline

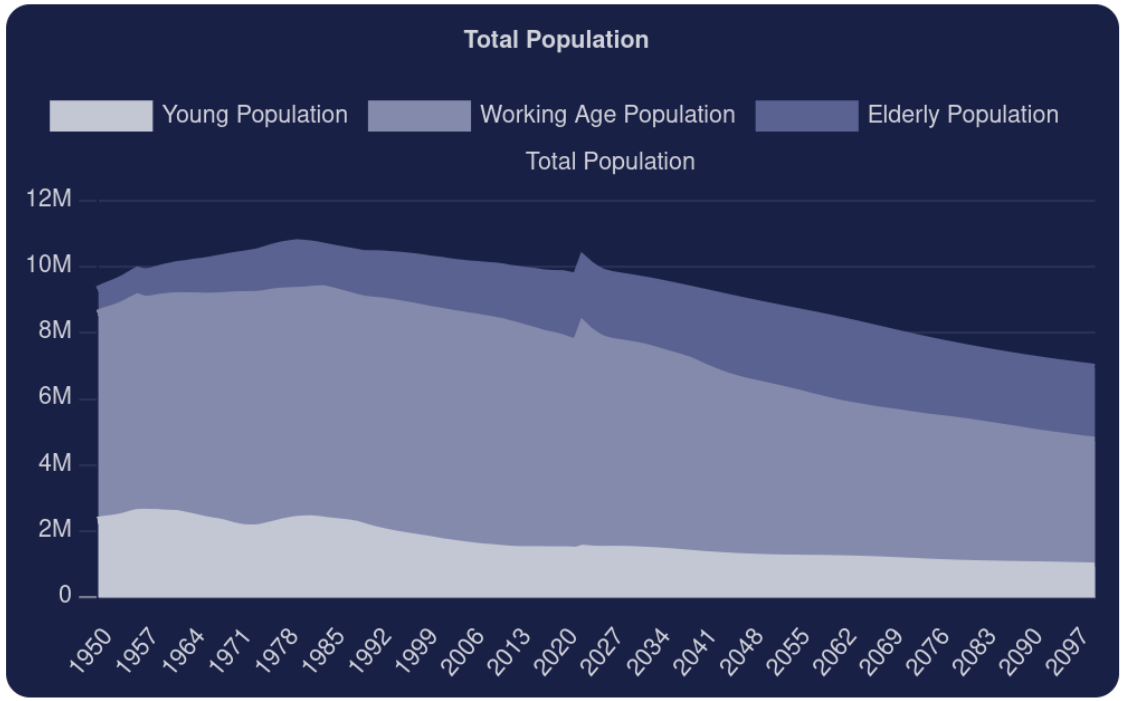
Future Circular Collider Timeline

Question #5?

Who?

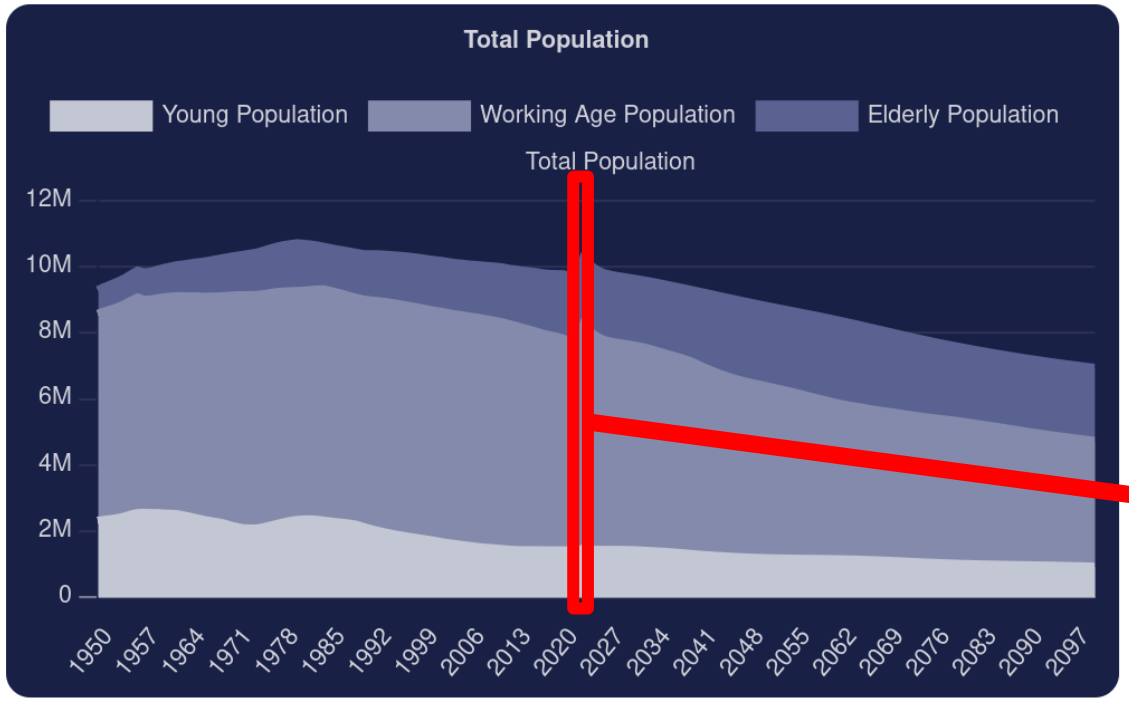
Who will play the role?

- Population data 1950-2097* (KSH)



Who will play the role?

- Population data 1950-2097* (KSH) vs CERN Graybook



Hungary

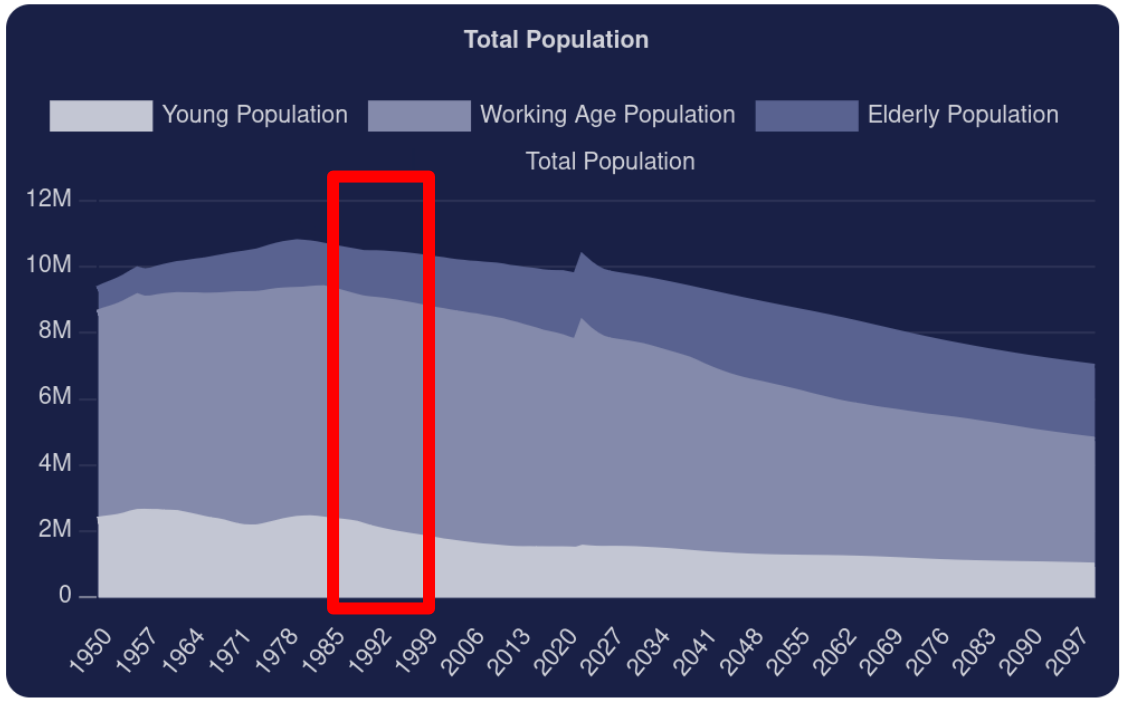
Overview | Experiments | Institutes | Teams | Participations

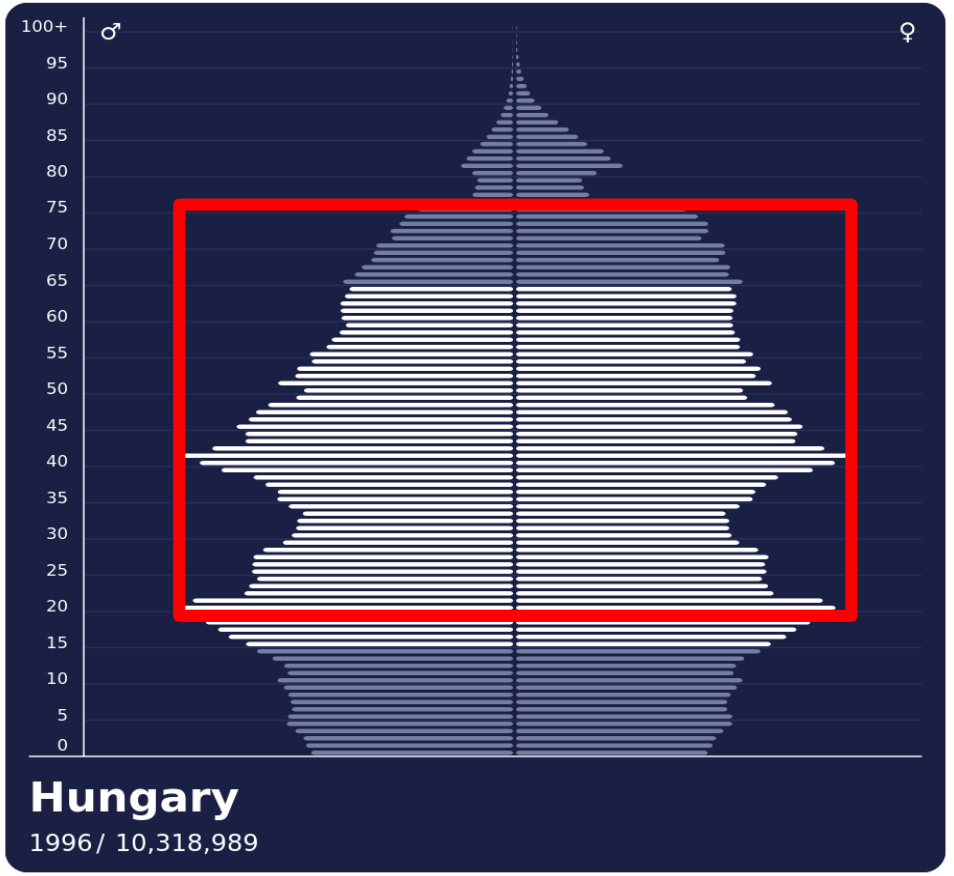
Number of Experiments:	15
Number of Institutes:	7
Number of Teams:	23
Number of Authors:	48
Total number of participants:	111
Users:	82
External Participants:	26
Other Participants:	3

0.0017%

Who will play the role?

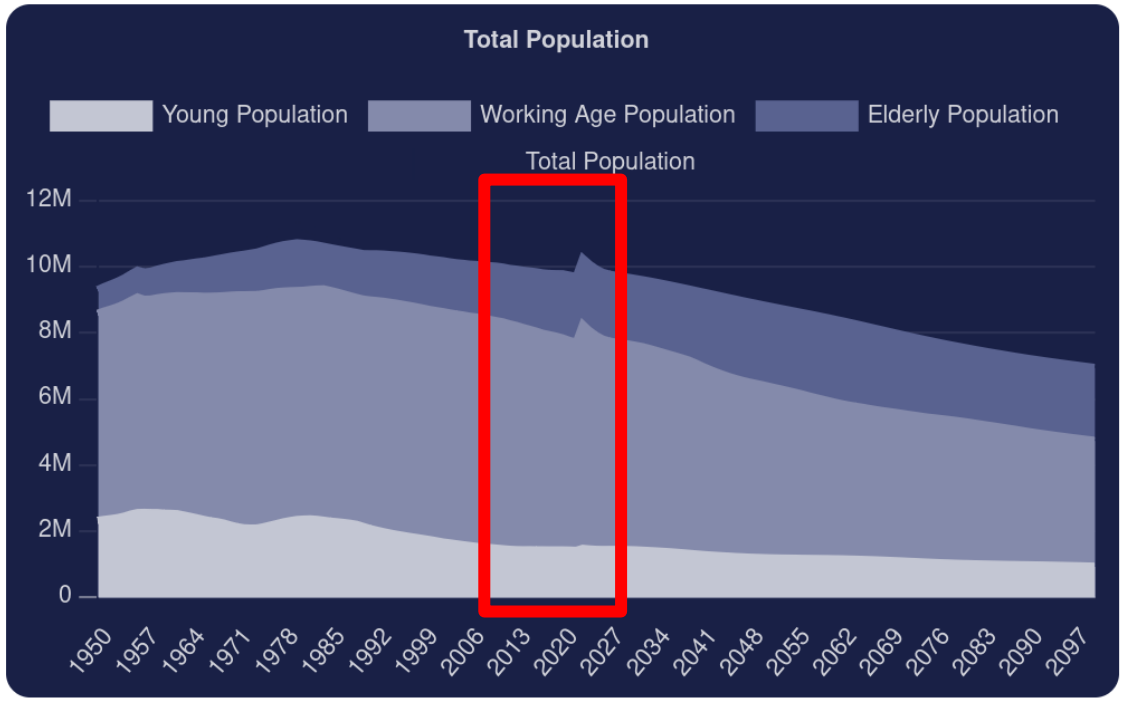
- Population data at the time of LEP

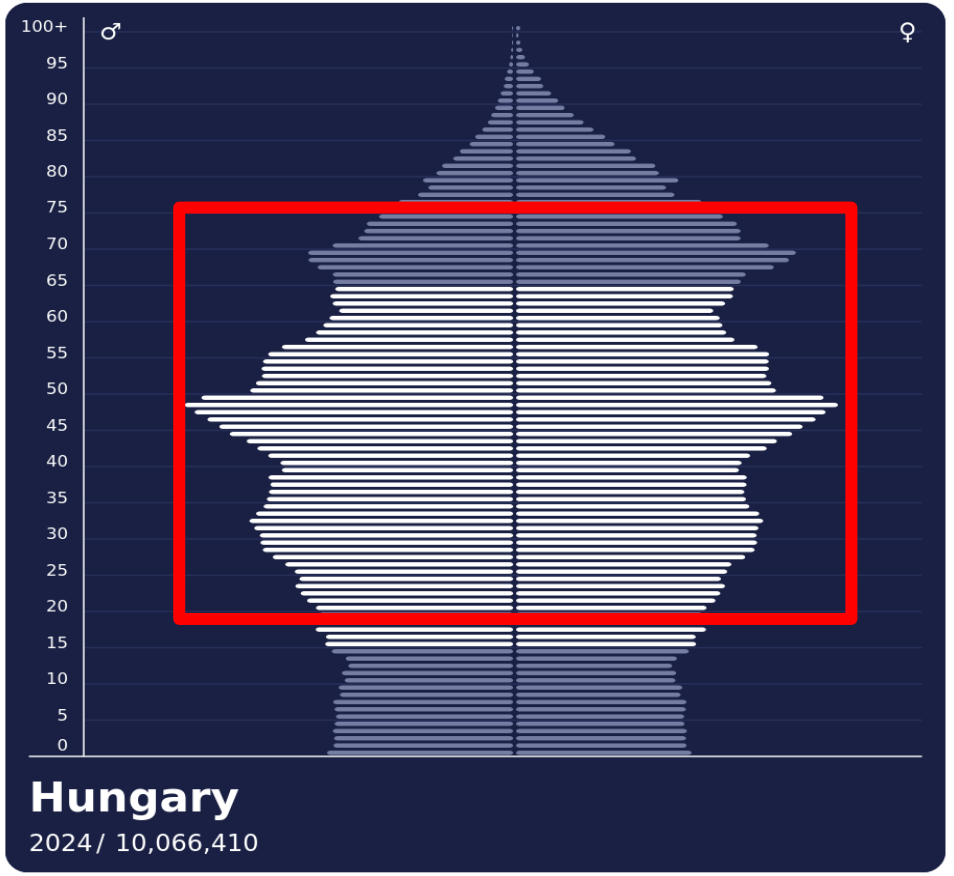




Who will play the role?

- Population data at the time of LHC

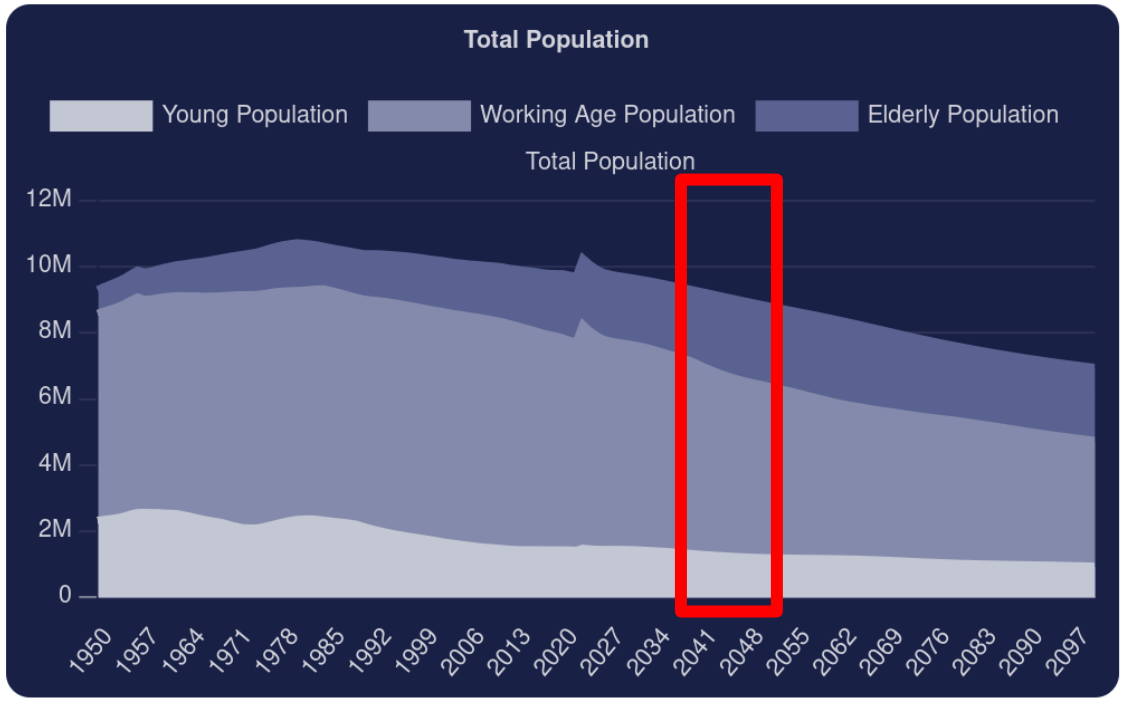


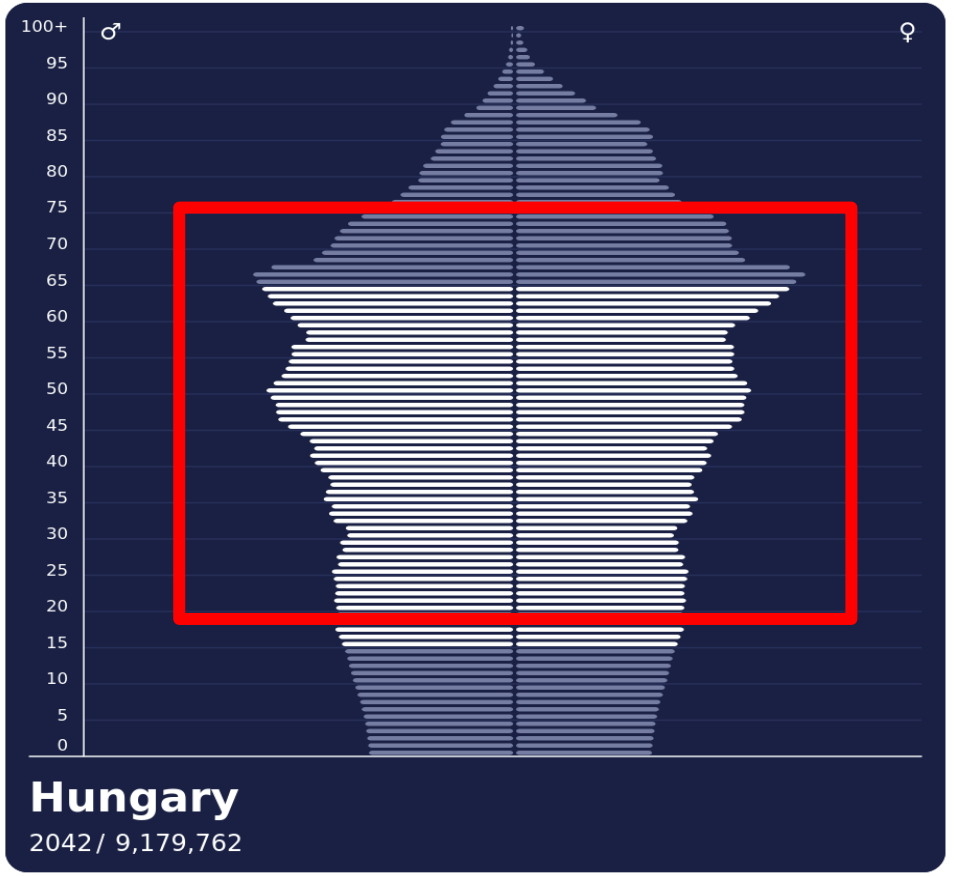


111 user

Who will play the role?

- Population data at the time of HL LHC (end)





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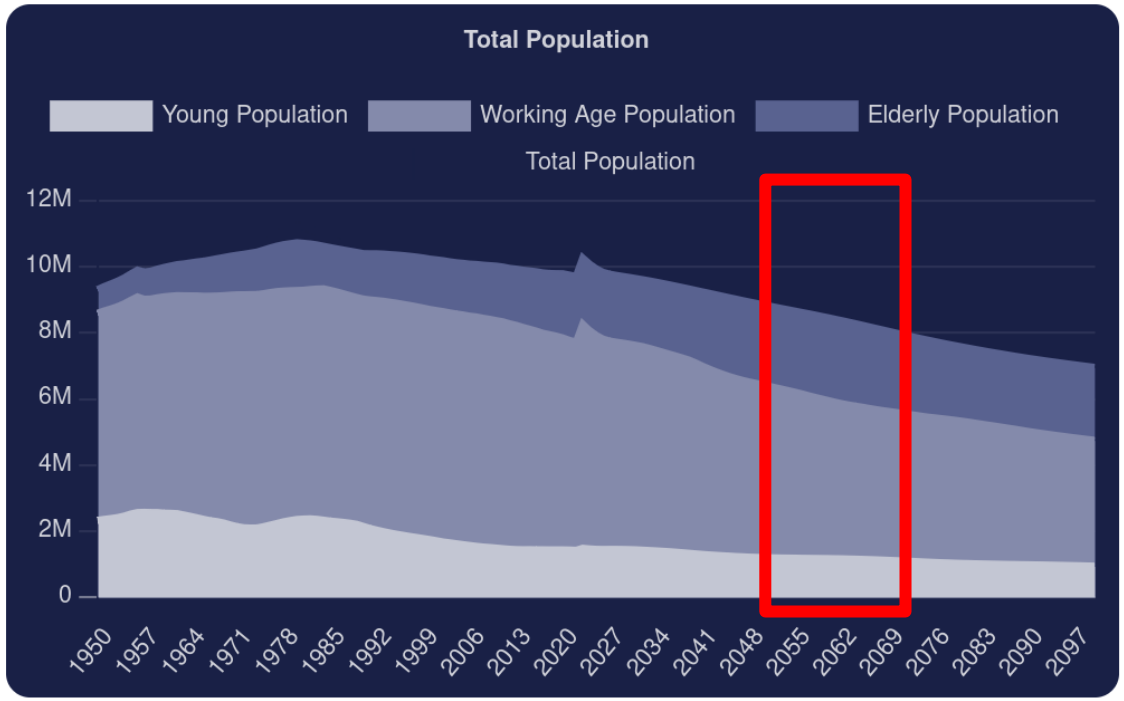
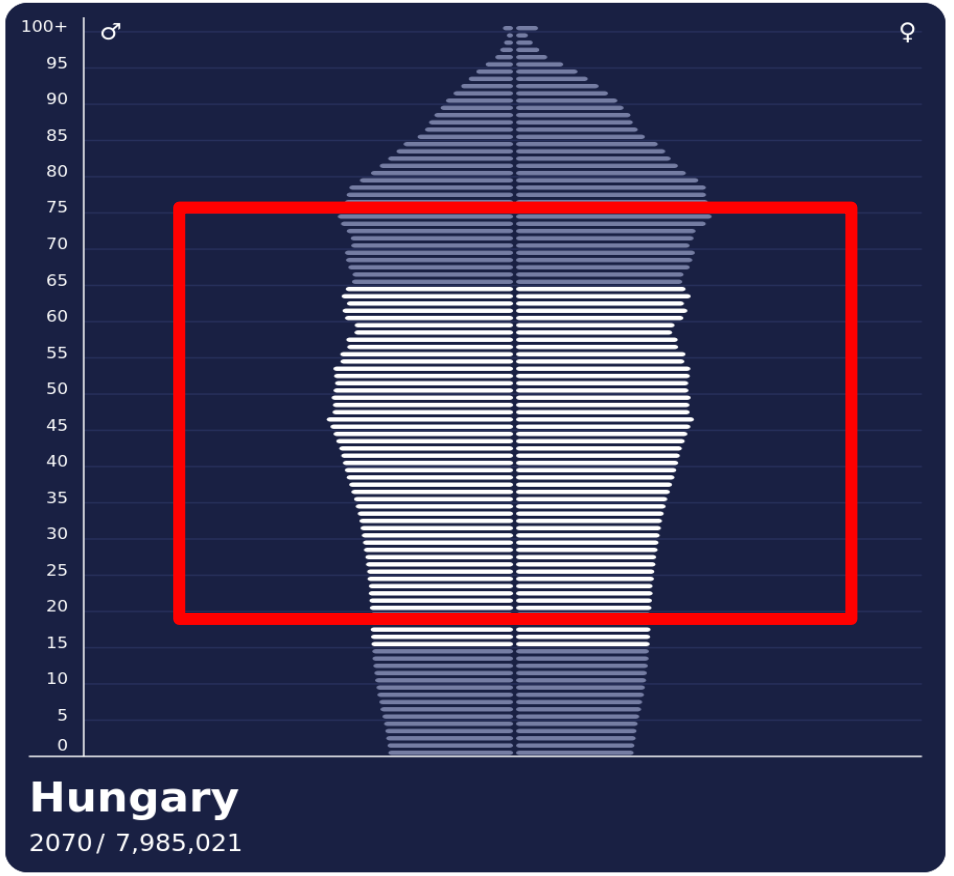
Who will play the role?

- Population data at the time of FCC-hh





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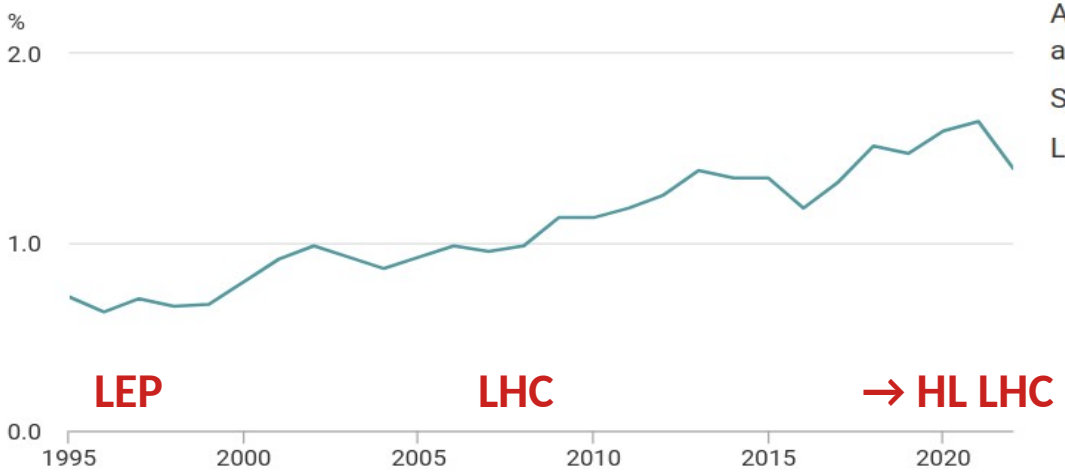
Who will pay the role?

Science and technology

To increase the stock of scientific knowledge on man, society, environment and technology is an important tool to improve the quality of life and competitiveness. These activities are covered by R&D statistics, providing information among others on the number of research and development units, employment in R&D activities, the amount and sources of expenditure as well as the results of research and development. We collect data on the innovation activities of enterprises – relying on the results of R&D in many cases – every two years, in the frame of the innovation survey of the Community, harmonised at EU level.

1.39 %	1.14 %	0.69 %	30.2 %
R&D expenditure as a percentage of GDP 2022	Number of staff performing R&D activities, as a percentage of total employment 2022	R&D capital expenditure as a percentage of investments in the national economy 2022	Proportion of innovation-active enterprises 2020–2022

R&D expenditure as a percentage of GDP



Indicator description

Amount of R&D expenditure (R&D current costs and R&D capital expenditure) as a proportion of gross domestic product (GDP) in a particular year.

Source of data: Summary Tables (STADAT)

Last data for period: 2022

Who will pay the role?

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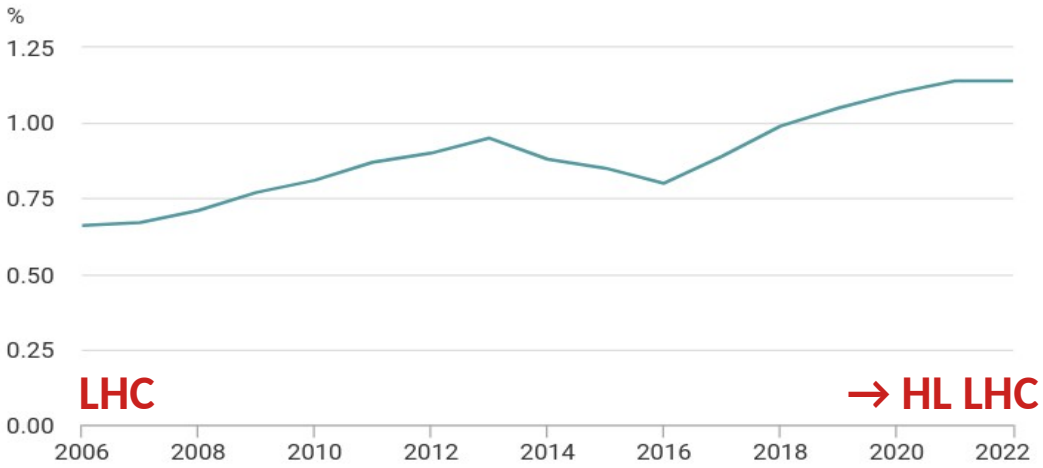
R&D staff number as a percentage of total employment



Indicator description

Internal R&D staff in full-time equivalents as a proportion of total employment.

Source of data: Summary Tables (STADAT)

Last data for period: 2022

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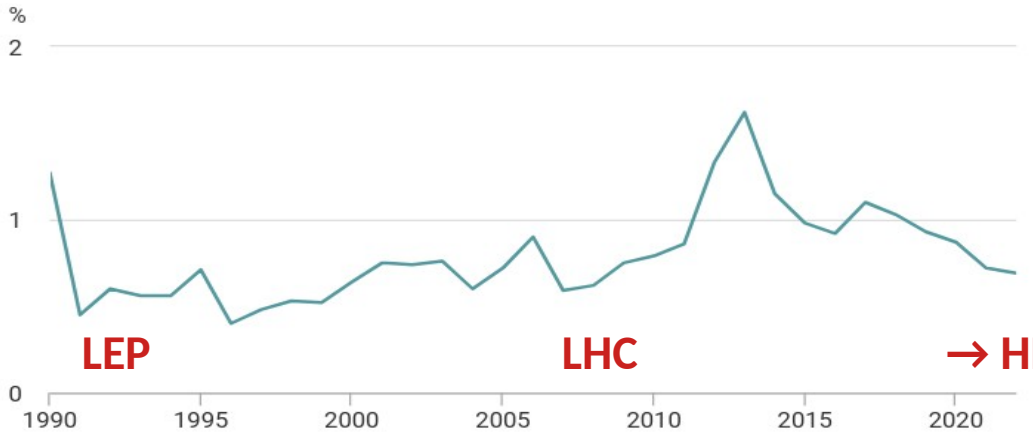
R&D capital expenditure as a percentage of investments in national economy



Indicator description

R&D capital expenditure as a proportion of total economic investments in current year. R&D capital expenditure is the value (excluding VAT) of purchases in the current year of tangible assets and computer software used directly in research and development activities.

Source of data: Summary Tables (STADAT)

Last data for period: 2022

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Science and technology

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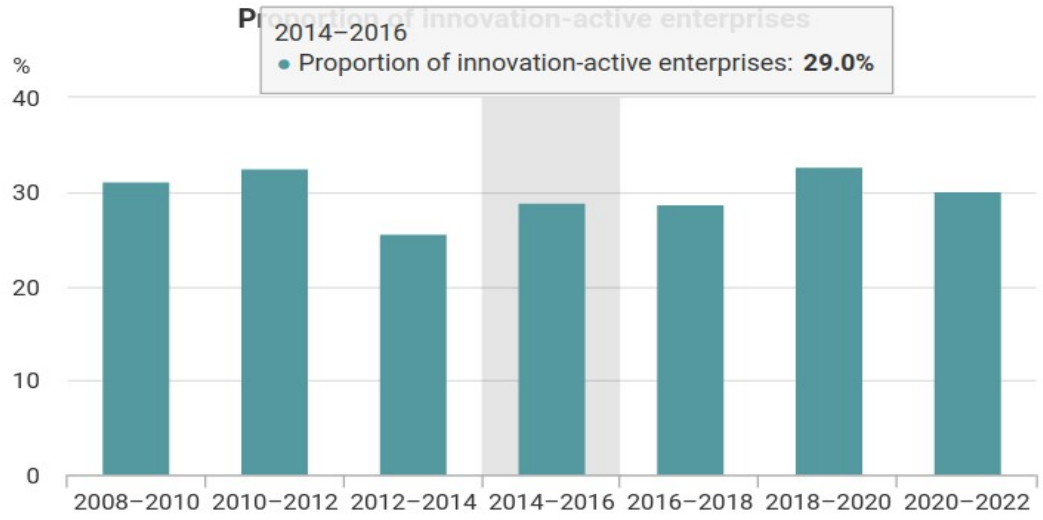


Indicator description

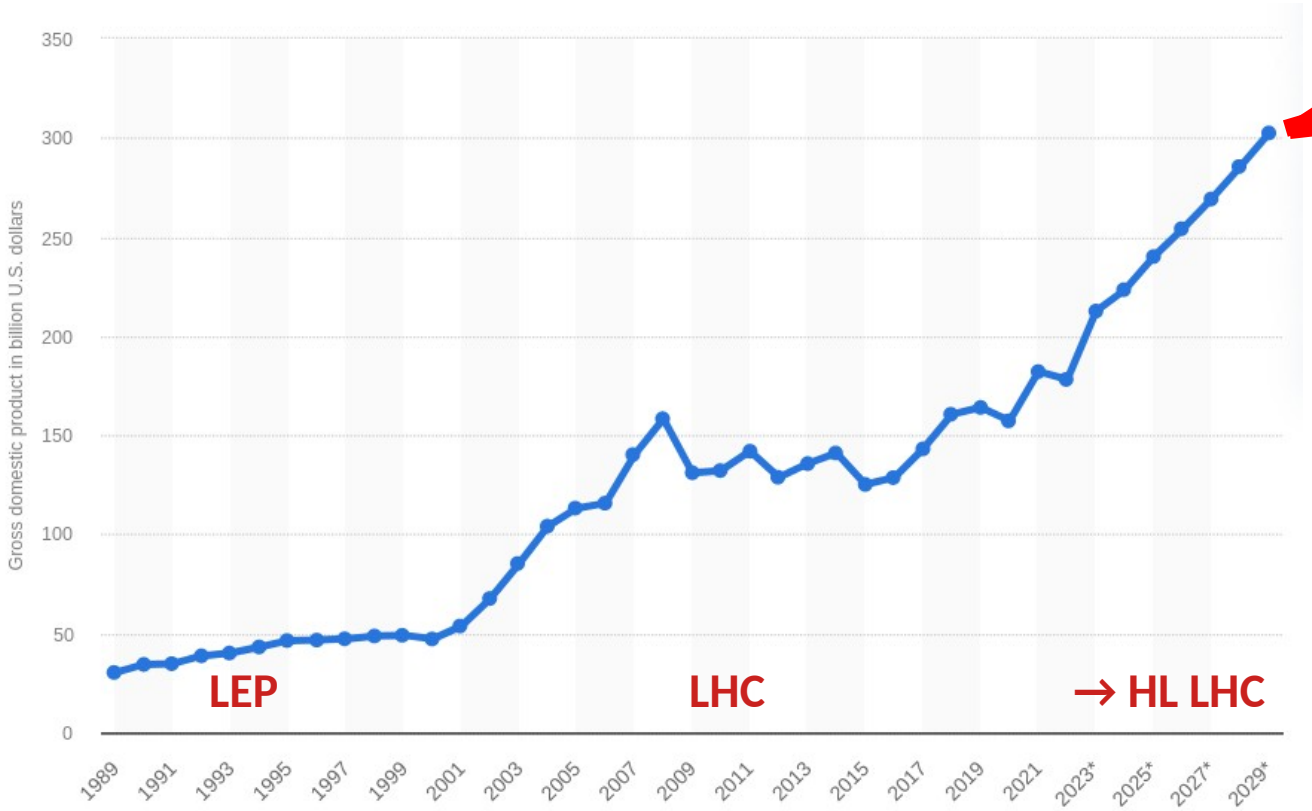
Enterprises which engaged at some time during the observed period in one or more innovation activities to develop or implement new or improved products or business processes for an intended use, as a proportion of all enterprises employing at least 10 people. Innovation activities include all developmental, financial and commercial activities undertaken by an enterprise that are intended for or result in an innovation for the enterprise.

Source of data: Summary Tables (STADAT)

Last data for period: 2020–2022

Who will pay the role?

- Hungarian GDP (1999-2024*)



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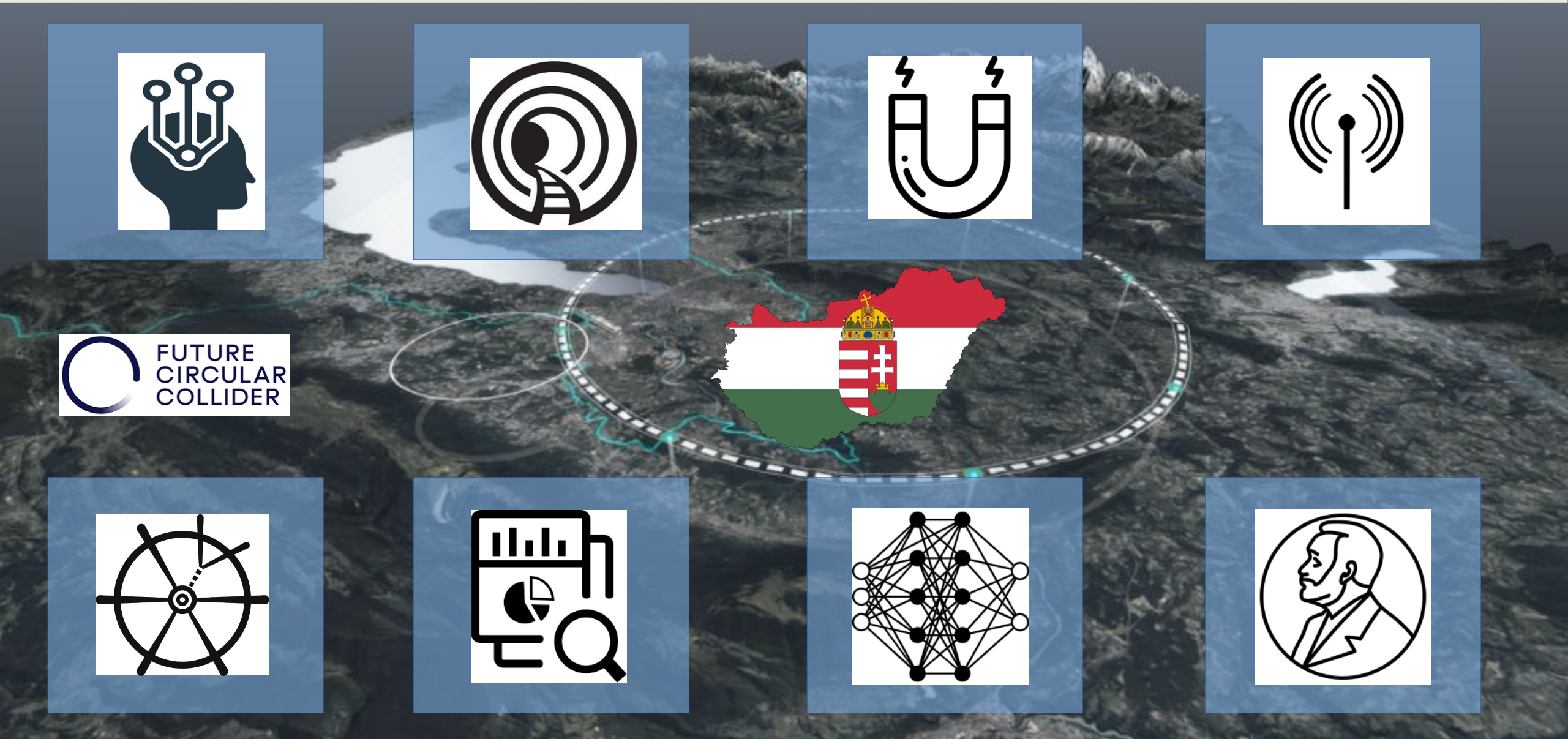
Question #6?

How?

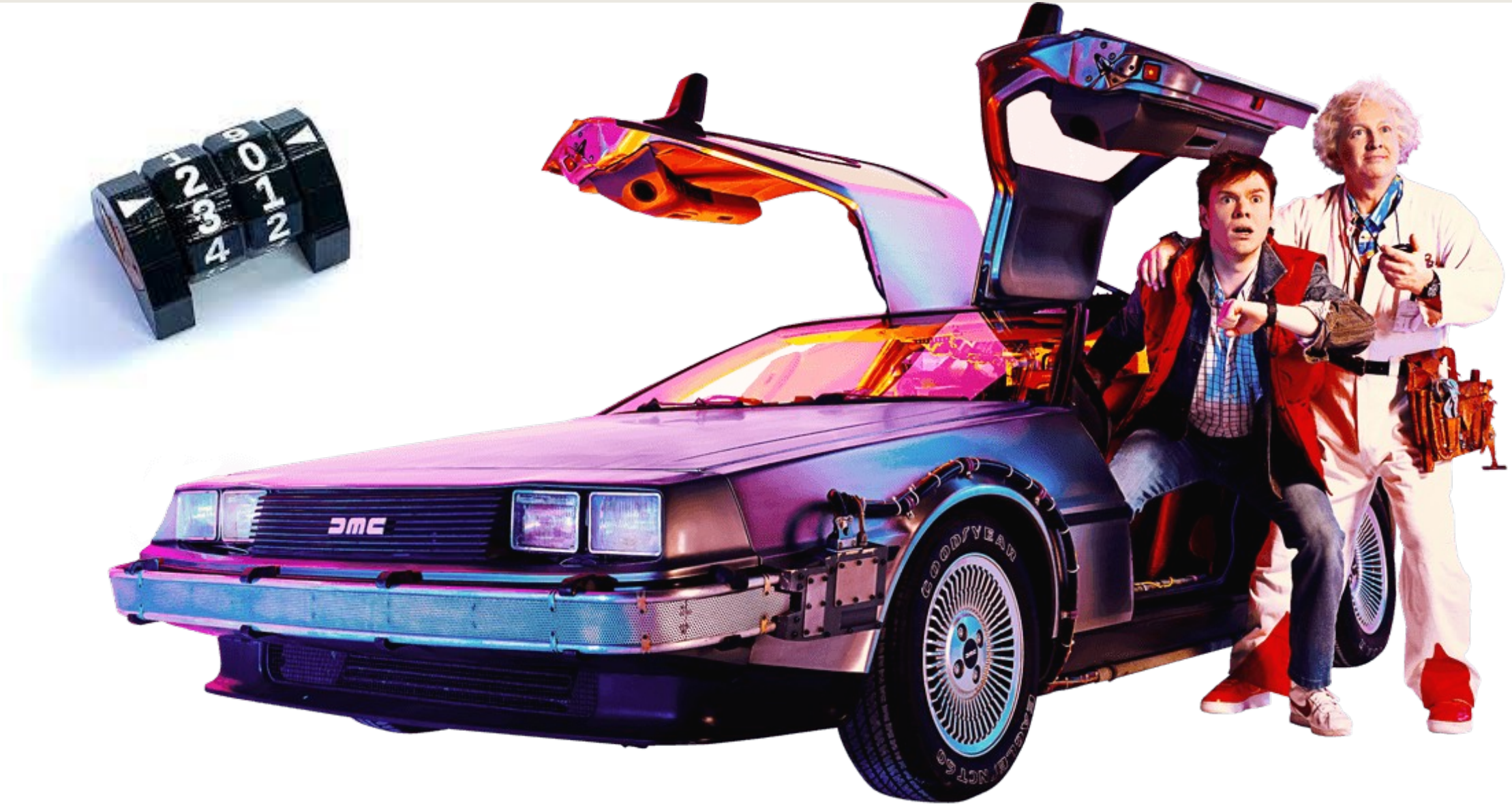
How can Hungary contribute?



Preparatory phase & Outreach

- In FCC since the beginning
  - Connection to the activities, especially FCC-hh
  - Kicker magnet design (see D. Barna)
  - Main interest is on FCC-hh detector development & simualtion
- Outreach activities since
  - 2019 Adacemy of Omniscience (National Broadcast Service MTVA)
  - 2018 FCC @ from Atoms to Stars (AtomCsill)
  - 2019 2nd MTA Podcast + Daily newspapers
  - 2020 Savers of the Future (TV)
  - 2019-2023 several High School visits

How would this look like in 2042?

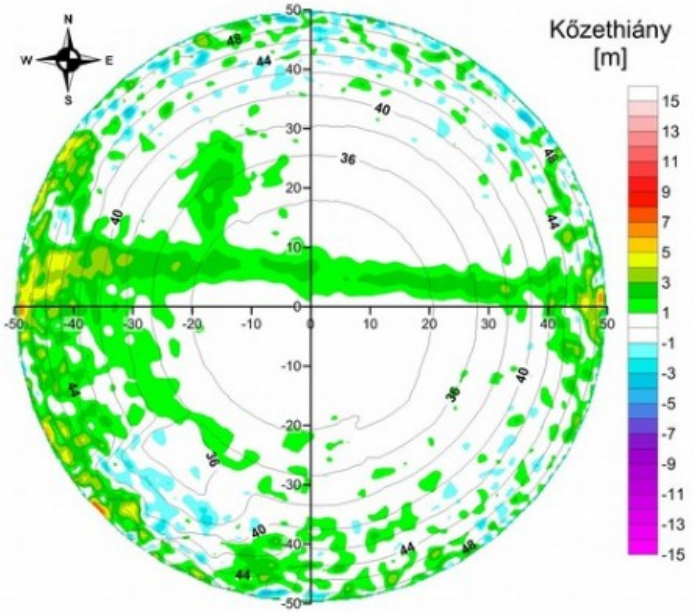


Civil engineering with applied HEP

- Wannabe …
  - Cosmic muon tomography since 2009 (ReGaRD)
  - Application in: speleology, vulcanology, civil engineering
  - Today big interest in Mining Technology (D. Varga)

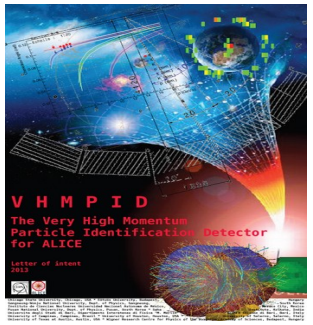
From lab…

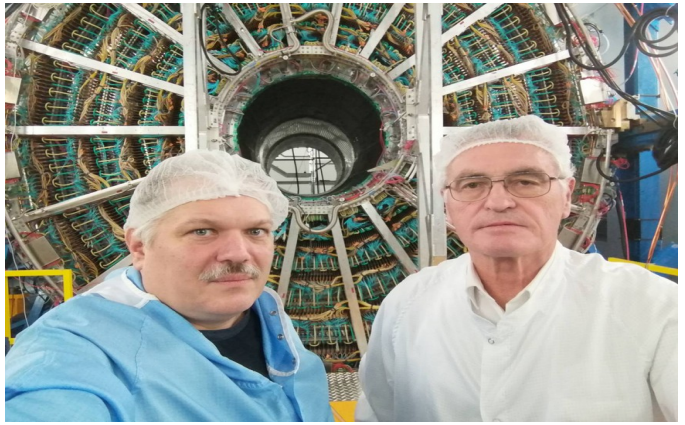
… to an operational mine



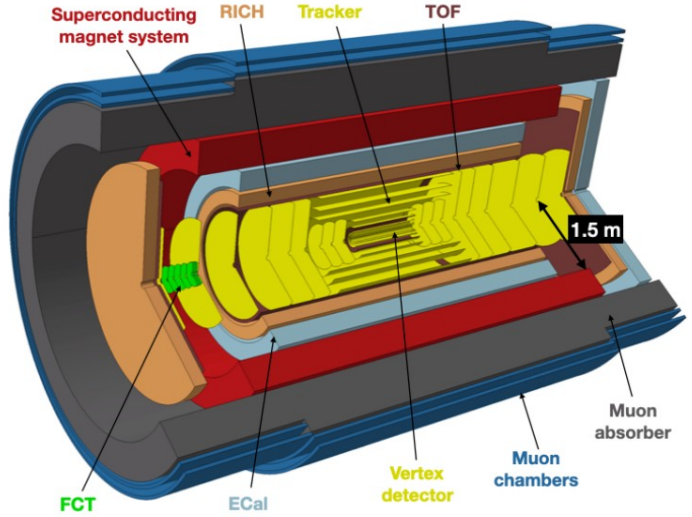
Continuous participation in Detector R&D

- DRD1 – gaseous detectors
  - ALICE HMPID & VHMPID
  - ALICE TPC UG
  - ALICE2 FoCAL
  - ALICE3 Muon ID UG



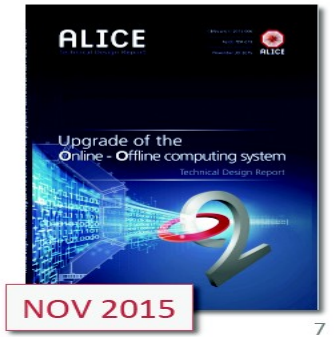


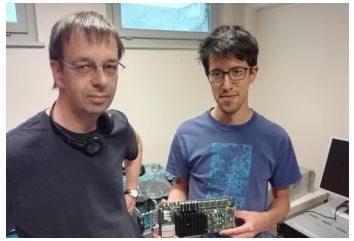
- DRD5 – quantum sensing & technology
  - Participation in CERN QTI Phase #1
  - Plans to continue with CERN QTI Phase #2
  - Special interest in Quantum Networks

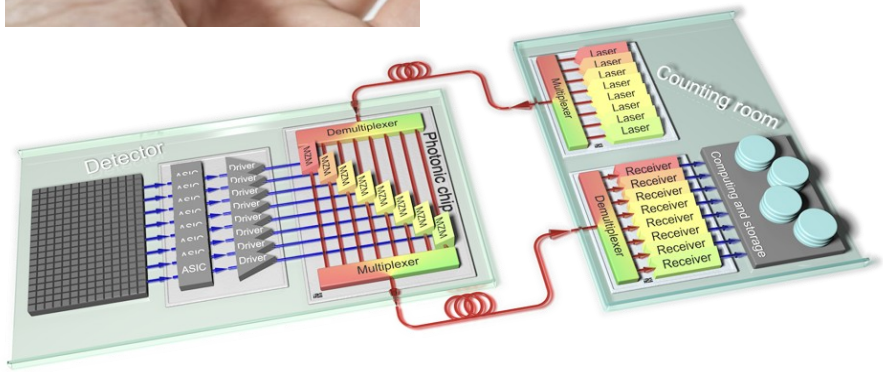


Innovative IT solutions

- Trigger & Firmware
  - 2000 ALICE DAQ Design, R&D, firmware
  - 2020 ALICE DAQ UG (O2) Design, coordination, firmware
  - 2024 ALICE DAQ proposal replacing GBT → lpGBP+ (Versatile+)
  - ALICE2 FoCal, ITS3 & ALICE3 MID, RICH, ….?
  - NextGen Trigger solution







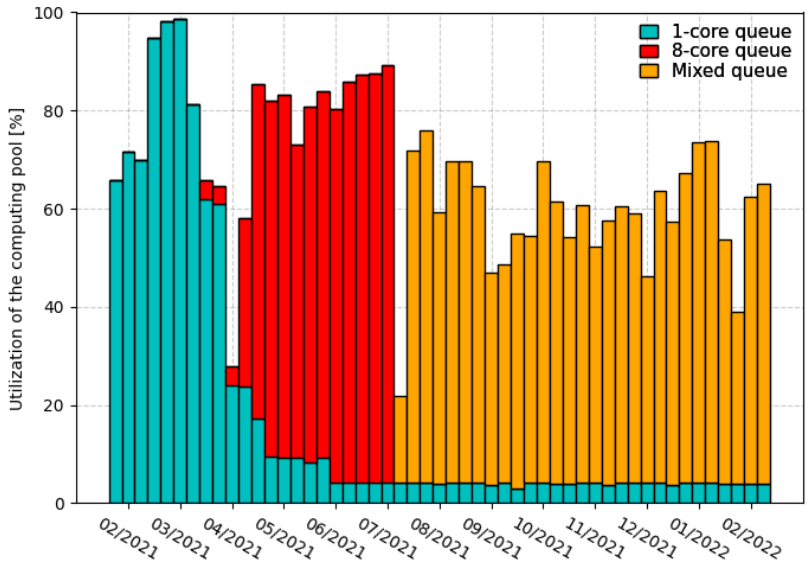
Innovative IT solutions

- Hardware
  - Wigner Data Center (T0 for CERN)
  - EuroHPC amd JENAA collaboration (plan: LEVENTE 20 PFlop)
  - WSCLAB Massive parallel & quantum computing (GPGPU, FPGA)
  - Wigner Analysis Facility for ALICE (1st hyperloop)

The Wigner ALICE Analysis Facility

Gábor Bíró[1,2], Gergely Gábor Barnaföldi[1], Péter Lévai[1], Latchezar Betev[3] and Jan Fiete Grosse-Oetringhaus[3]

[1]Wigner Research Center for Physics, 29–33 Konkoly–Thege Miklós Str., H-1121 Budapest, Hungary.
[2]Institute of Physics, Eötvös Loránd University, 1/A Pázmány Péter Sétány, H-1117 Budapest, Hungary.
[3]European Organization for Nuclear Research (CERN), Geneva, Switzerland.



Innovative IT solutions

- Software
  - GeantV Project (vectorization)
  - HEPMC (parallel MC generator HIJING++)

Heavy
Ion
Jet
INteraction
Generator

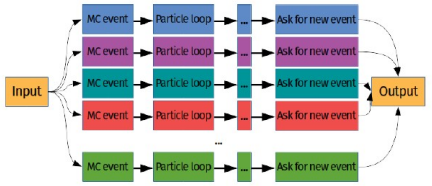
核易经

[Hé –yì –jīng]

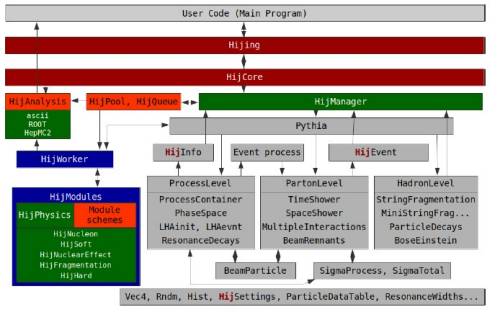
"Nuclear change theory"; Book of Changes, "Originally a divination manual in the Western Zhou period (1000–750 BC)"

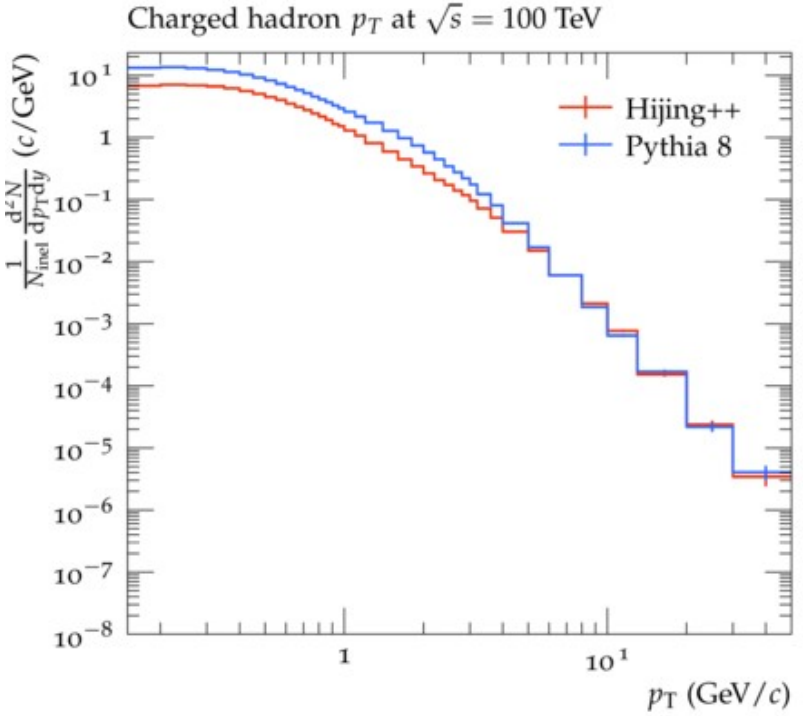
First, FORTRAN version: 1991, X.N. Wang, M. Gyulassy, **Phys. Rev. D** 44, (1991) 3501.

- Computational challenge: more than 600 million collision in **each second** → HiLumiLHC: even more
- Requirements for a new version: multithreaded mode, maintainability, intuitive usage



	FORTRAN HIJING	HIJING++ v3.0	HIJING++ v3.1
Precision	simple	double	double
Pythia version	5.3	8.2	8.2+
(n)PDF	GRV98lo	LHAPDF6.2	LHAPDF6.2+
Jet quenching	(✓)	(✓)	(✓)
Multithreading	✗	✗	✓
Analysis interface	✗	✗	✓
Module management	✗	✗	✓
Dependencies, build system	Makefile	Makefile	CMake

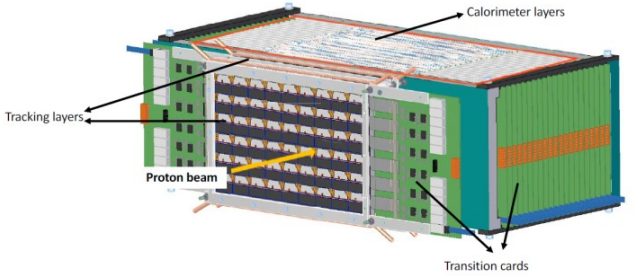




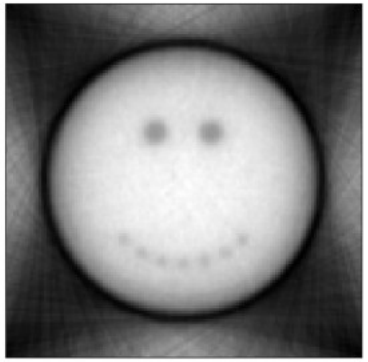
CPU	Release year	Cores (threads)	Base (turbo) frequency	TDP	RAM	Speedup pp	Speedup p-Pb	Speedup Pb-Pb
Intel® Core™ i5-8250U	Q3'17	4 (8)	1.6 GHz (3.4 GHz)	15 W	8 GB	2.6x	2.7x	2.6x
Intel® Xeon™ E3-1231 v3	Q2'14	4 (8)	3.4 GHz (3.8 GHz)	80 W	32 GB	6.4x	6.6x	4.5x

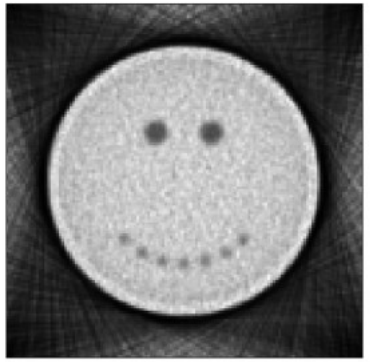
Innovative IT solutions

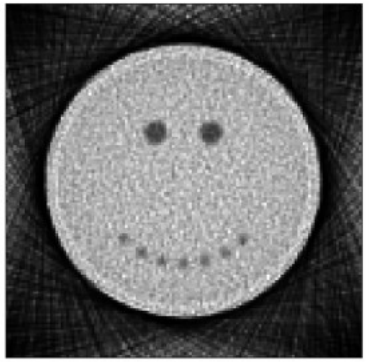
- Software
  - GeantV Project (vectotization)
  - HEPMC (parallel MC generator HIJING++)
  - HEPML (ML-based hadronization simulations)
  - Massively parallel computing (GPGPU FPGA)
  - ML-based tracking for Hadron Therapy
  - (Bergen pCT collaboration)



Front. in Phys. Med. Phys. Im. ID: 568243,
Nucl. Instrum. Methods Phys. Res. Im. ID: 162626







Summary

- In FCC R&D
  - Historically heavy-ion physics, detector R&D, DAQ, IT
  - Public outreach activities
  - Relation to DRD#1 and DRD#5
  - ALICE UG & ALICE3 activities
  - IT & Computing: EuroHPC, CERN QTI Phase 1
  - Massively parallel computing
  - New: NextGen, JENAA QTI Phase 2

See you and thanks for the...

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