

Experiment ALICE

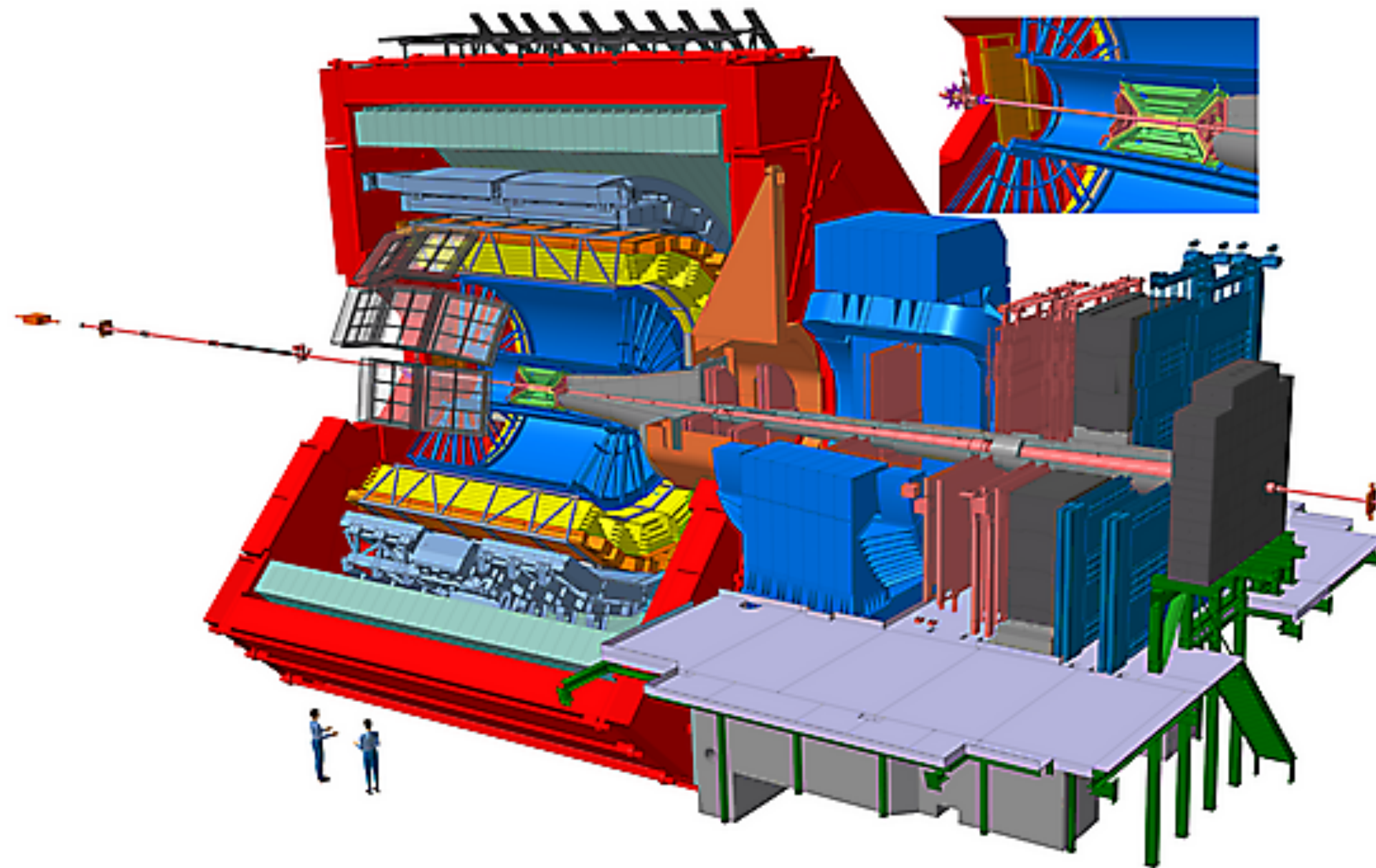
30 years of Slovak Republic at CERN



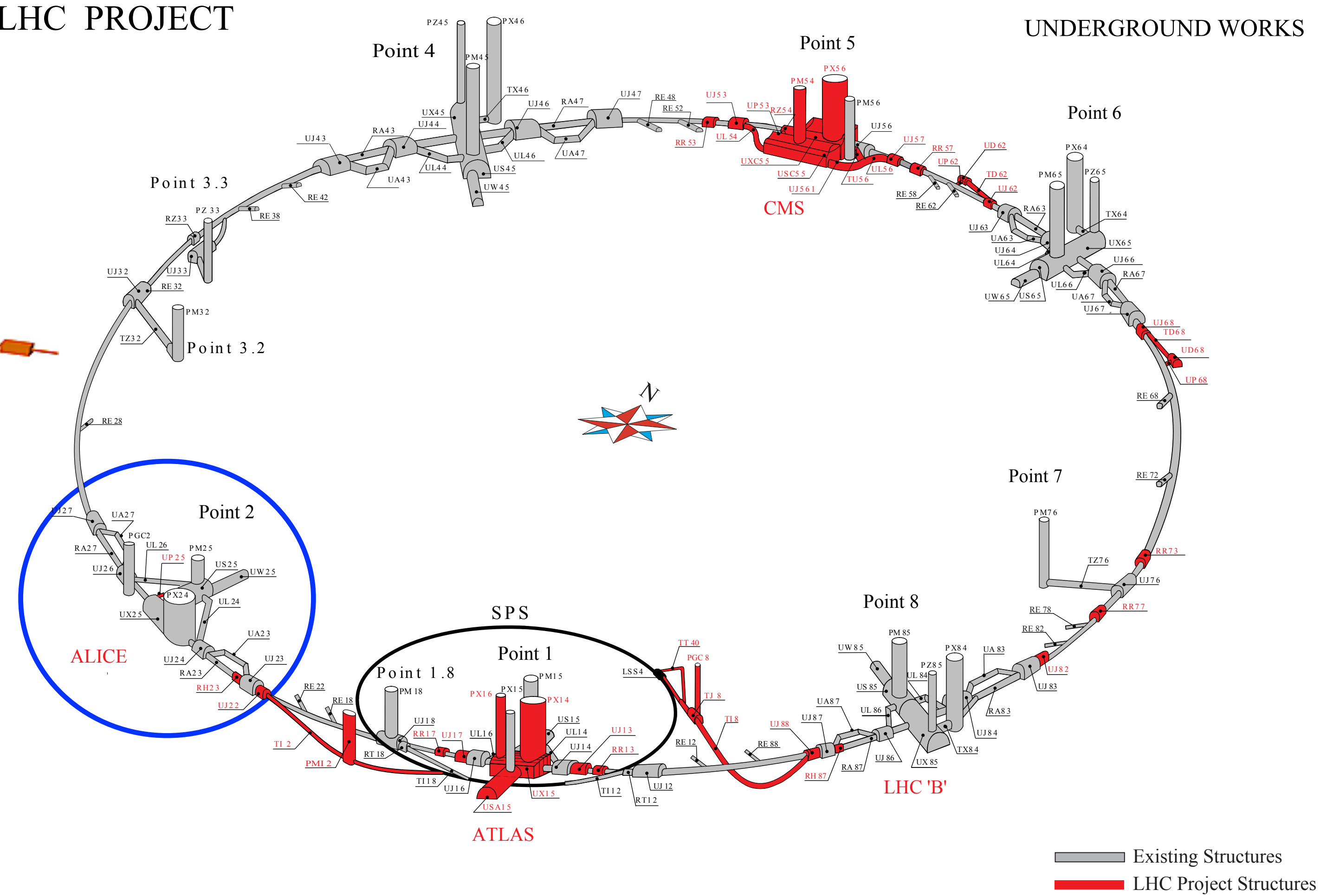
Marek Bombara, 27. 6. 2023, Bratislava



ALICE experiment at the Large Hadron Collider



LHC PROJECT



- dedicated to study hot and dense nuclear matter in heavy ion collisions
- crucial part of the physics programme is to study pp and p–Pb collisions

ST-CE/JLB-hlm
18/04/2003

Why do we study heavy-ion collisions?

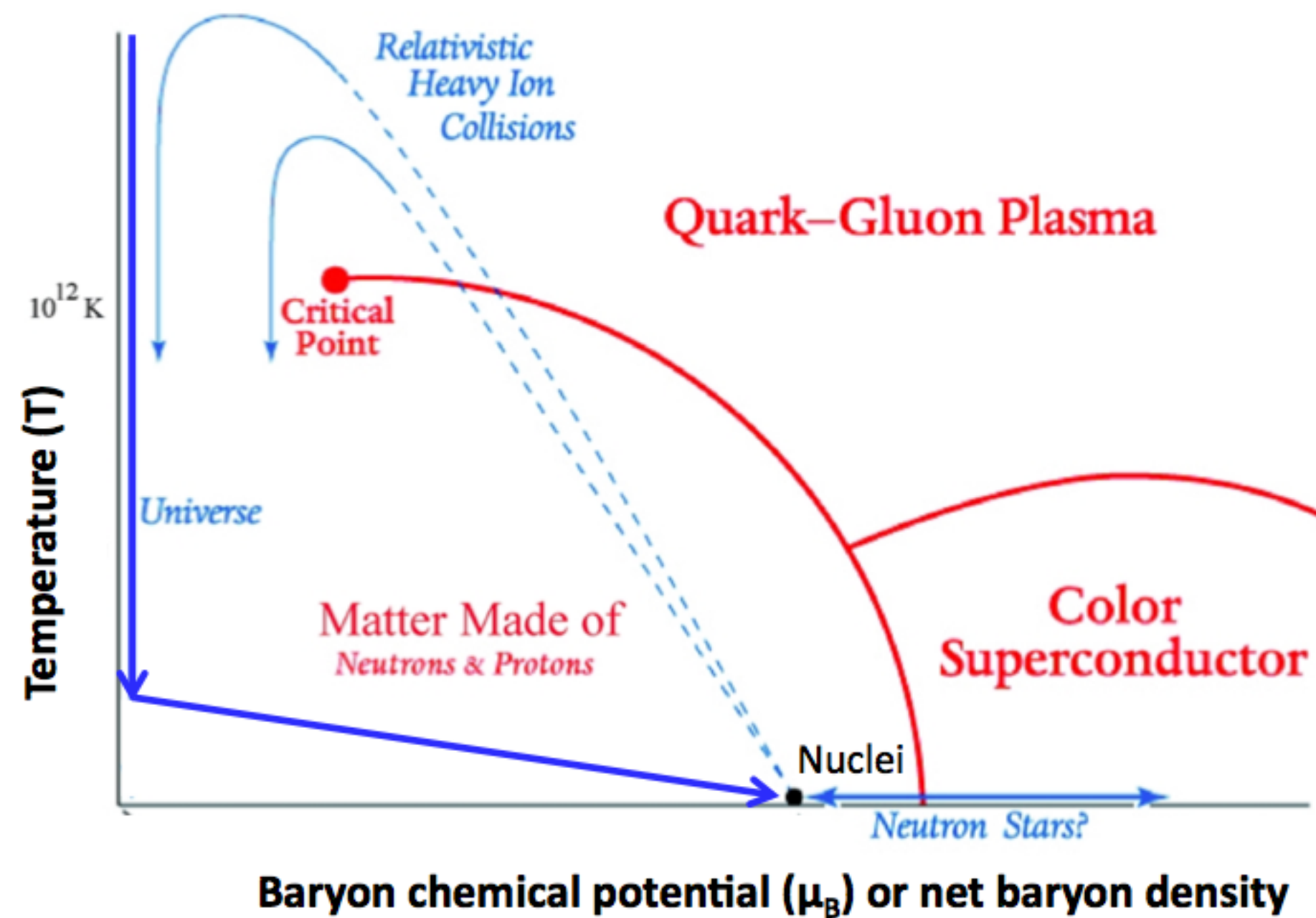
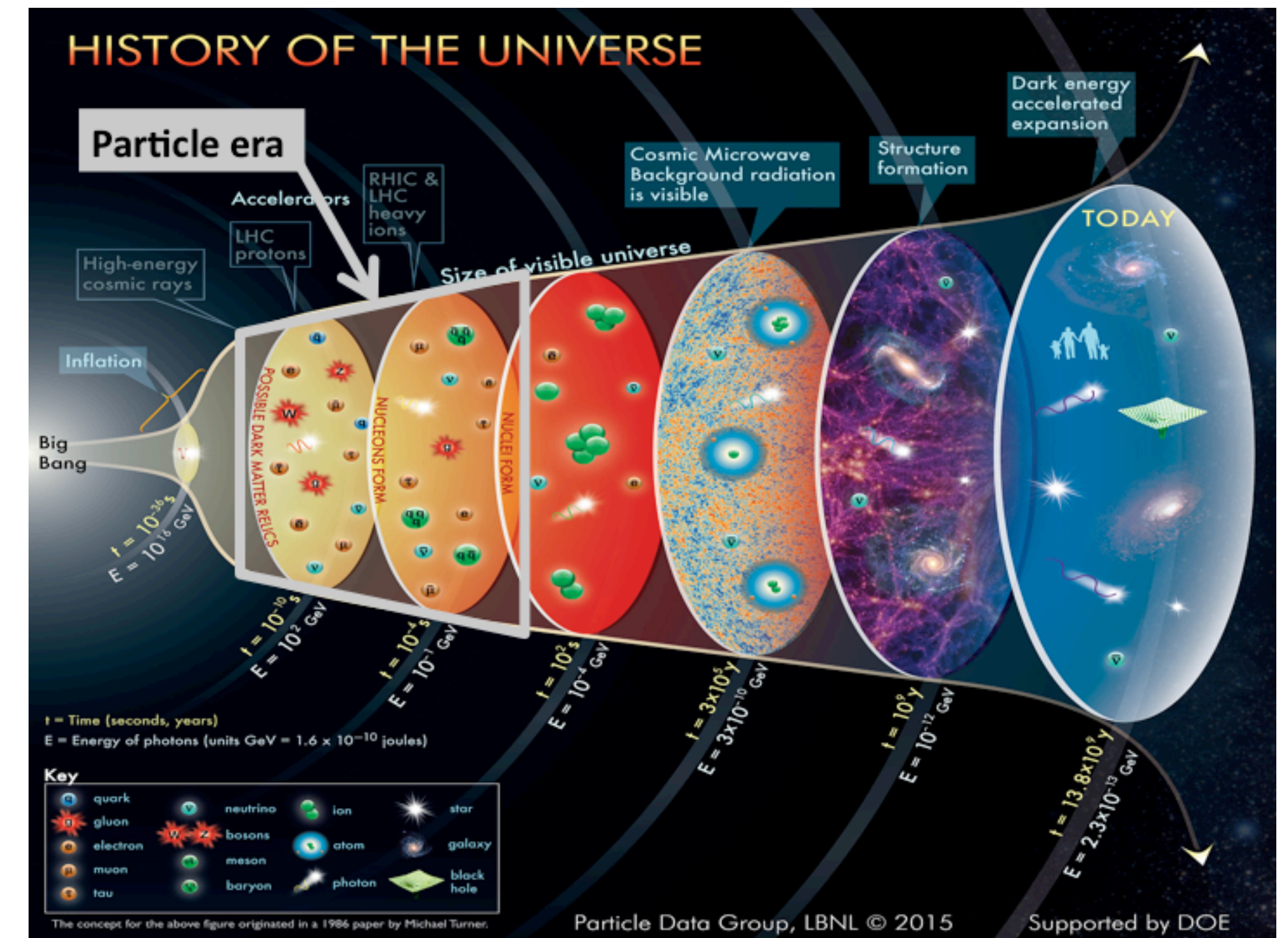
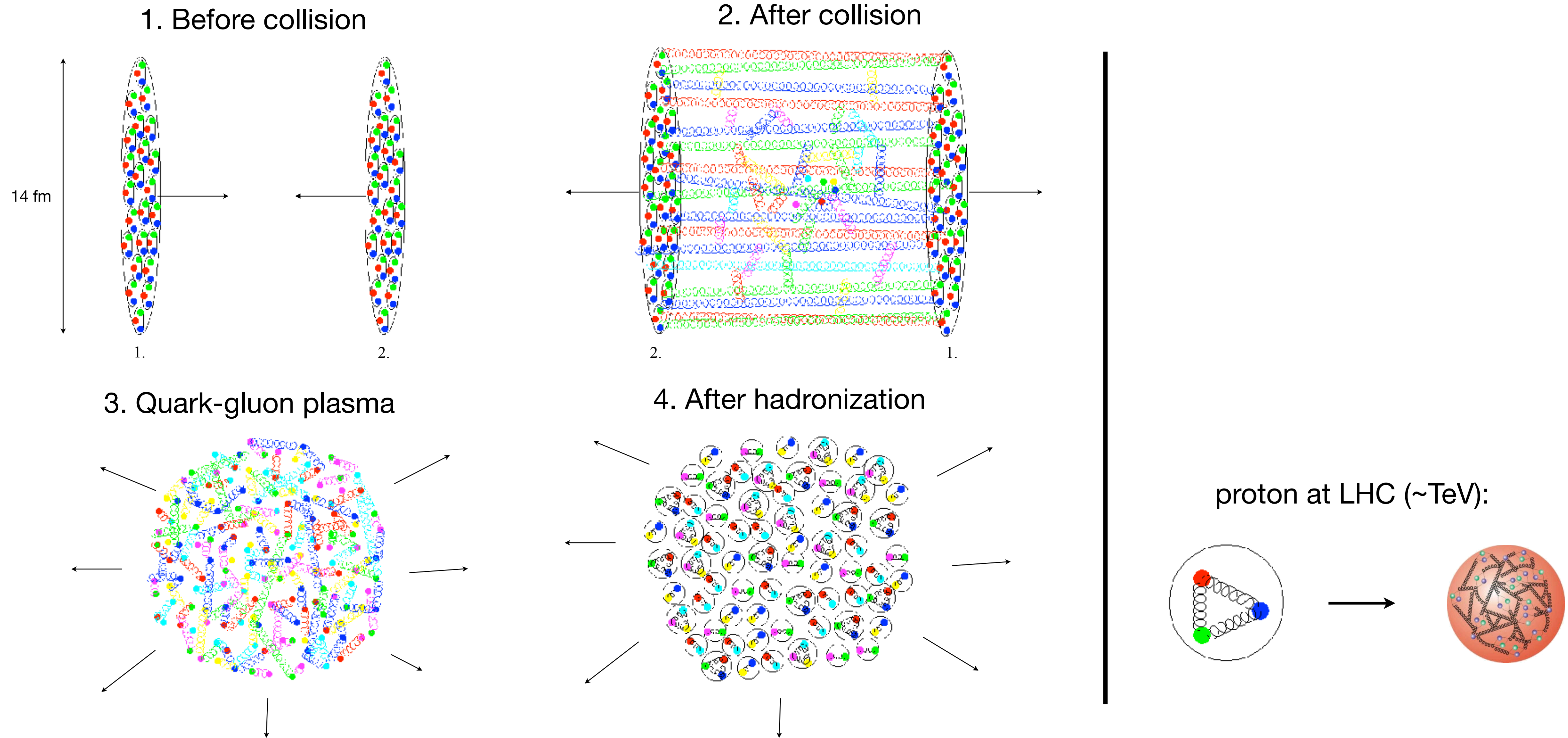


Fig: <http://inspirehep.net/record/1397855/plots>



- to explore the QCD matter phase diagram
- unique opportunity to study primordial matter from the Big Bang epoch in the laboratory

Little Bang in ultrarelativistic heavy ion collisions



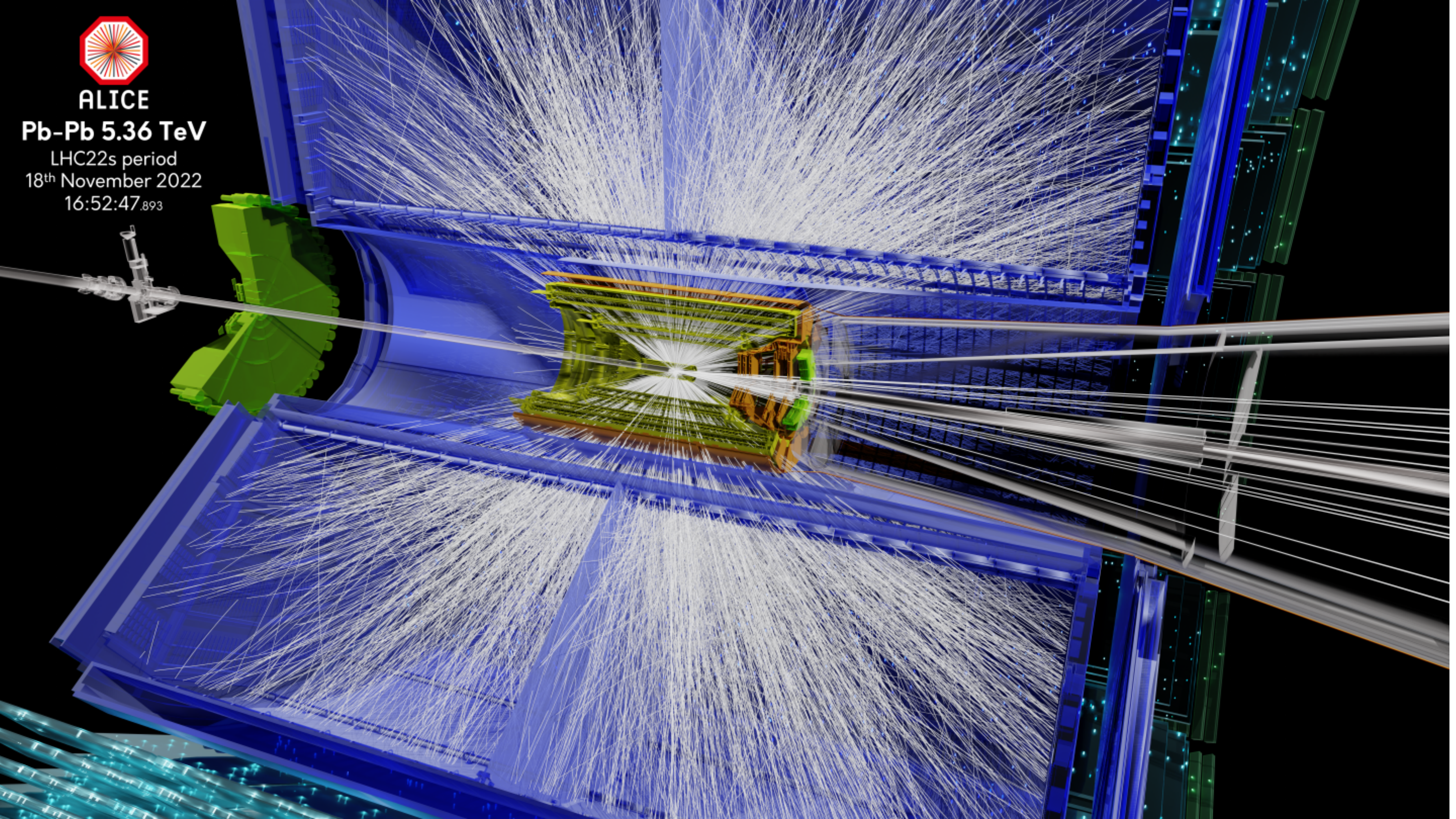


ALICE

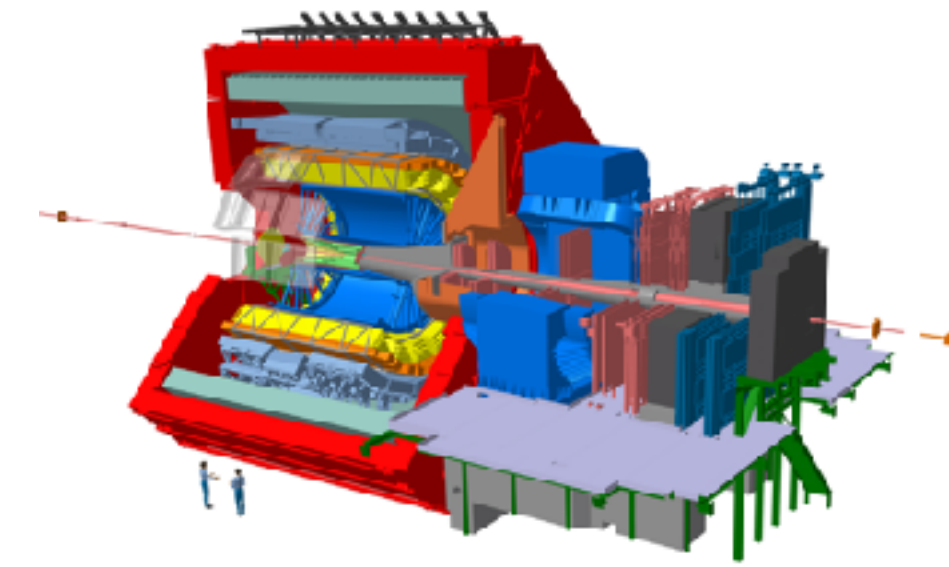
Pb-Pb 5.36 TeV

LHC22s period
18th November 2022

16:52:47.893



A glimpse of ALICE highlights

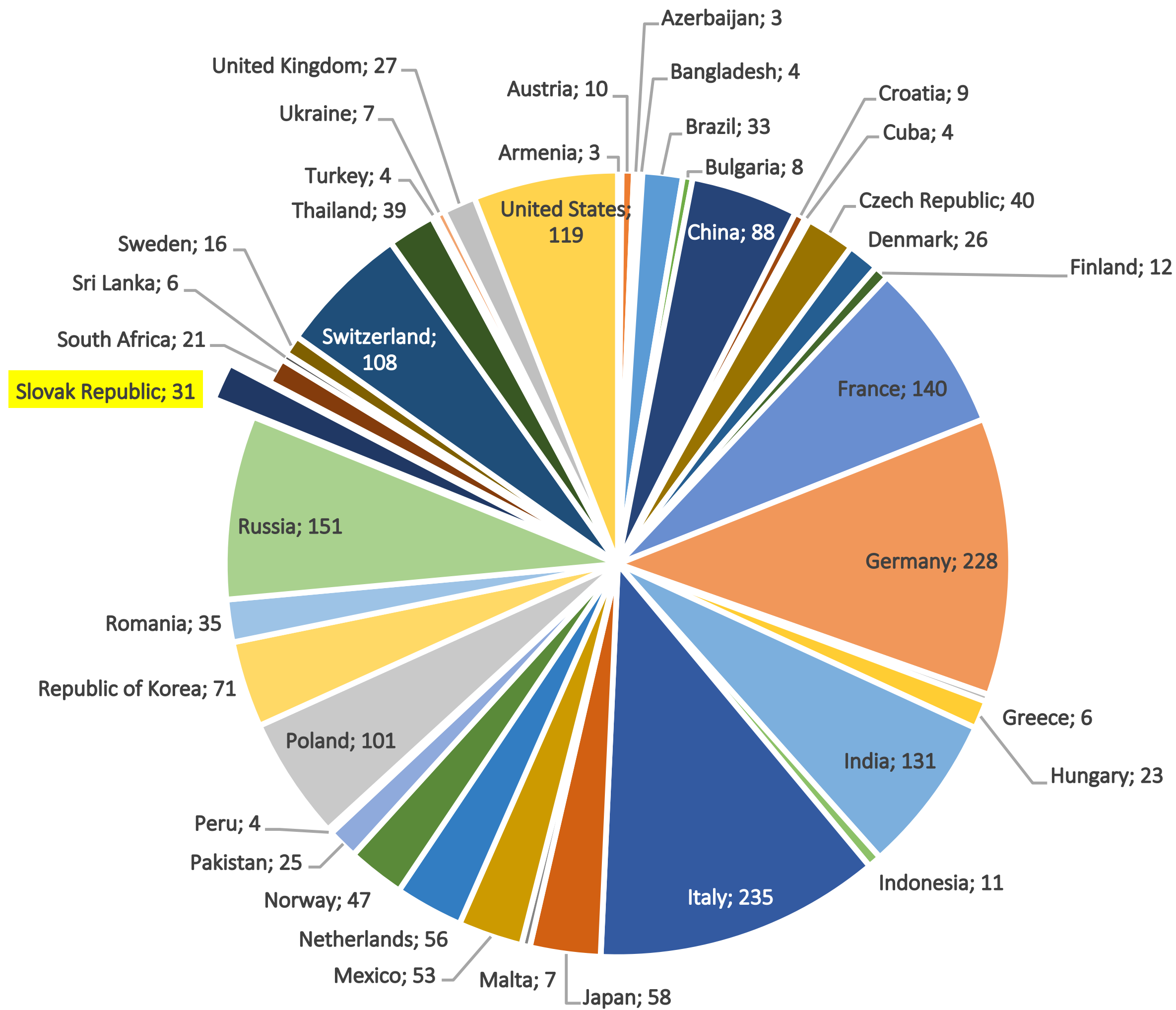


On 13 August 2012 scientists at CERN's Large Hadron Collider, Geneva, Switzerland, announced that they had achieved temperatures of over 5 trillion K and perhaps as high as 5.5 trillion K. The team had been using the ALICE experiment to smash together lead ions at 99% of the speed of light to create a quark gluon plasma – an exotic state of matter believed to have filled the universe just after the Big Bang.

Not only heavy ion experiment:

- in **small colliding systems** (QGP-like signatures): Enhanced production of multi-strange hadrons in high-multiplicity proton–proton collisions. [Nature Physics 13, 535–539 \(2017\)](#)
- in **Nuclear Physics** (CPT invariance in N-N interactions): Precision measurement of the mass difference between light nuclei and anti-nuclei. [Nature Physics, 11, 811–814 \(2015\)](#)
- additional **estimations for Dark Matter searches** (estimate of antinuclei production in cosmic rays): Measurement of the Low-Energy Antideuteron Inelastic Cross Section. [Physical Review Letters 125, 162001 \(2020\)](#)
- in **neutron stars** (hadron-hadron interactions in hyperon matter): Unveiling the strong interaction among hadrons at the LHC. [Nature 588, 232–238 \(2020\)](#)
- in **Quantum Chromodynamics**: Direct observation of the dead-cone effect in QCD. [Nature 605, 440–446 \(2022\)](#)

Slovak participation in ALICE



FMFI UK



Bratislava

Team Leader: Branislav Sitár

Members:

M. Mereš, M. Pikna, I. Szarka

PhD students

N. Džalaiová, M. Ivanov

2000 Members,
172 Institutes, 40 Countries

FS UPJŠ



IEP SAV



TUKE



Košice cluster

Team Leader: Ivan Králik

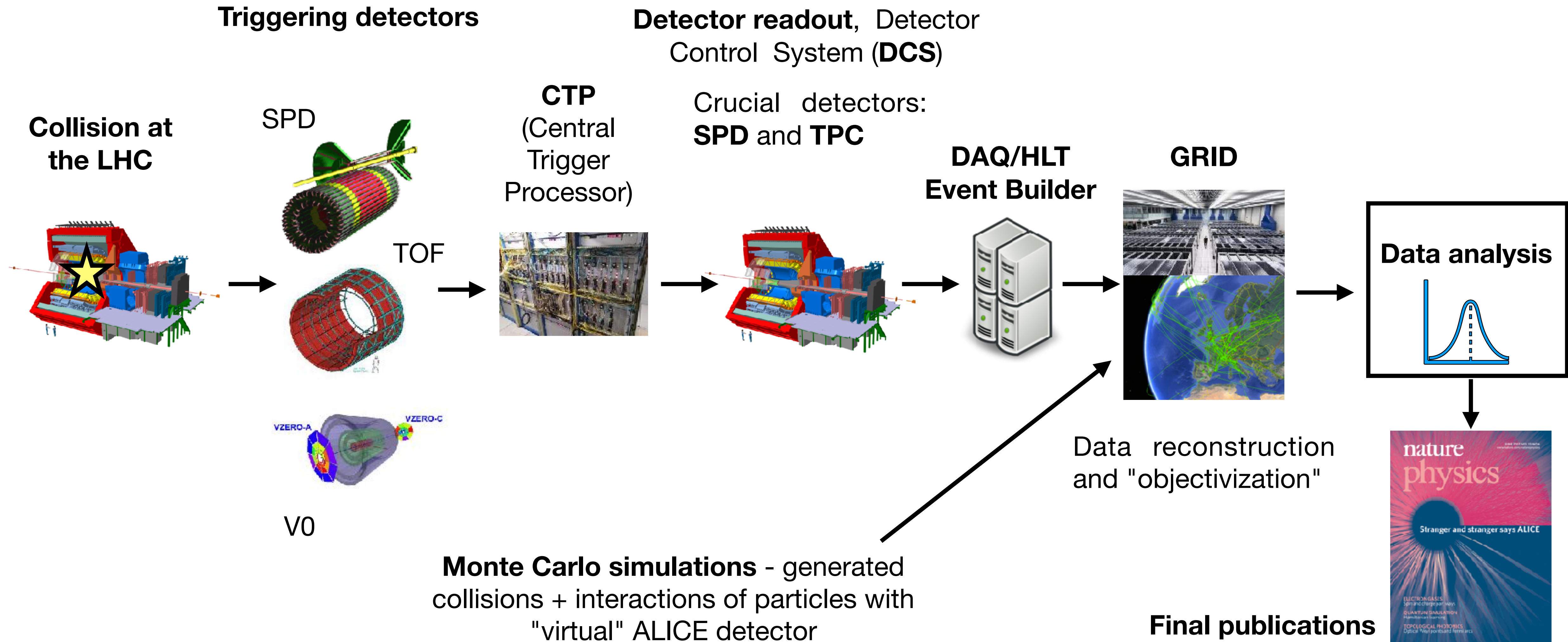
Members:

M. Bombara, A. Jadlovská, S. Jadlovská, J. Jadlovský, P. Kaliňák, A. Kravčáková, M. Krivda, J. Mušínský, M. Vaľa, J. Vrláková

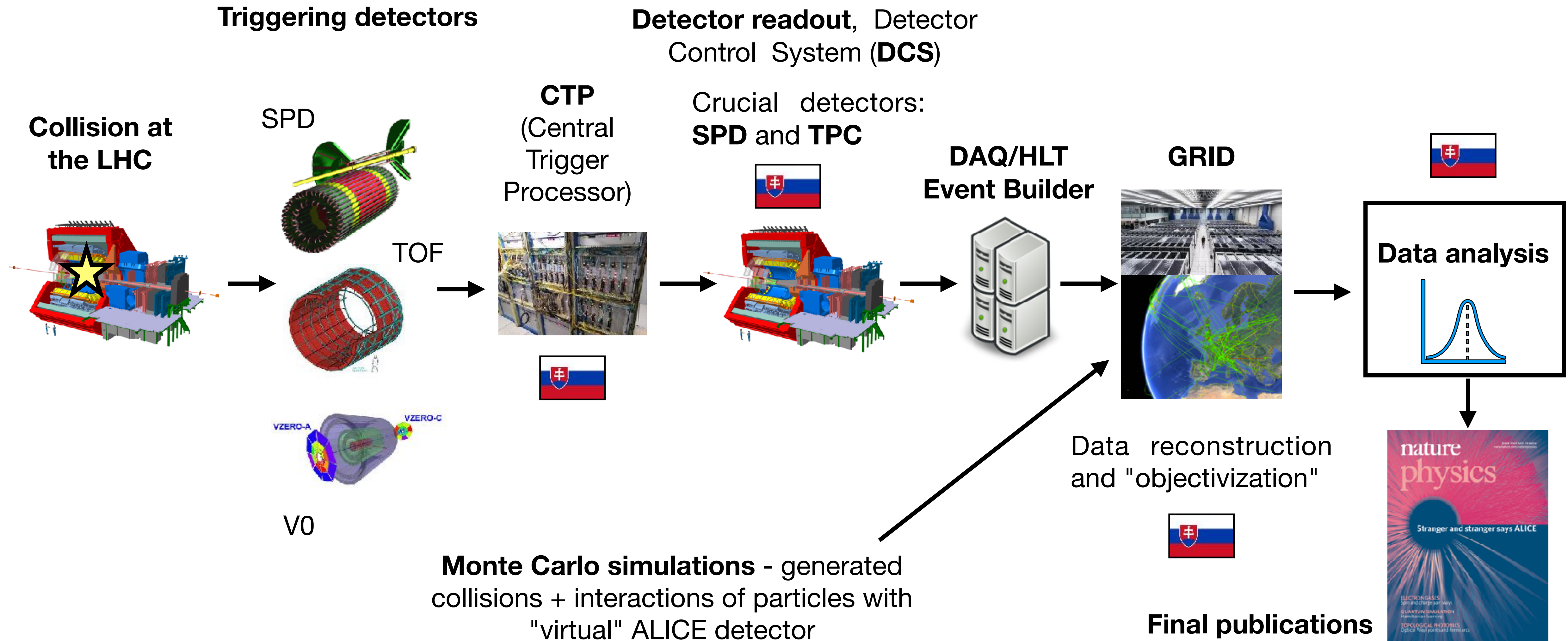
PhD students:

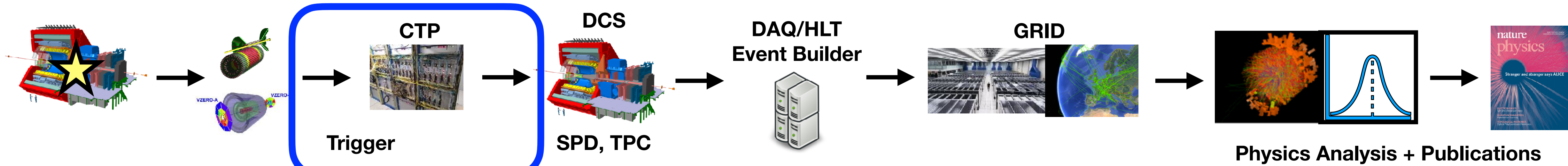
I. Ahuja, M. Tkáčik, T. Tkáčik, K. Tropp

ALICE Data flow story in Run1 (2009-2013), Run2 (2015-2018) and partially in Run3 (2022-2025)



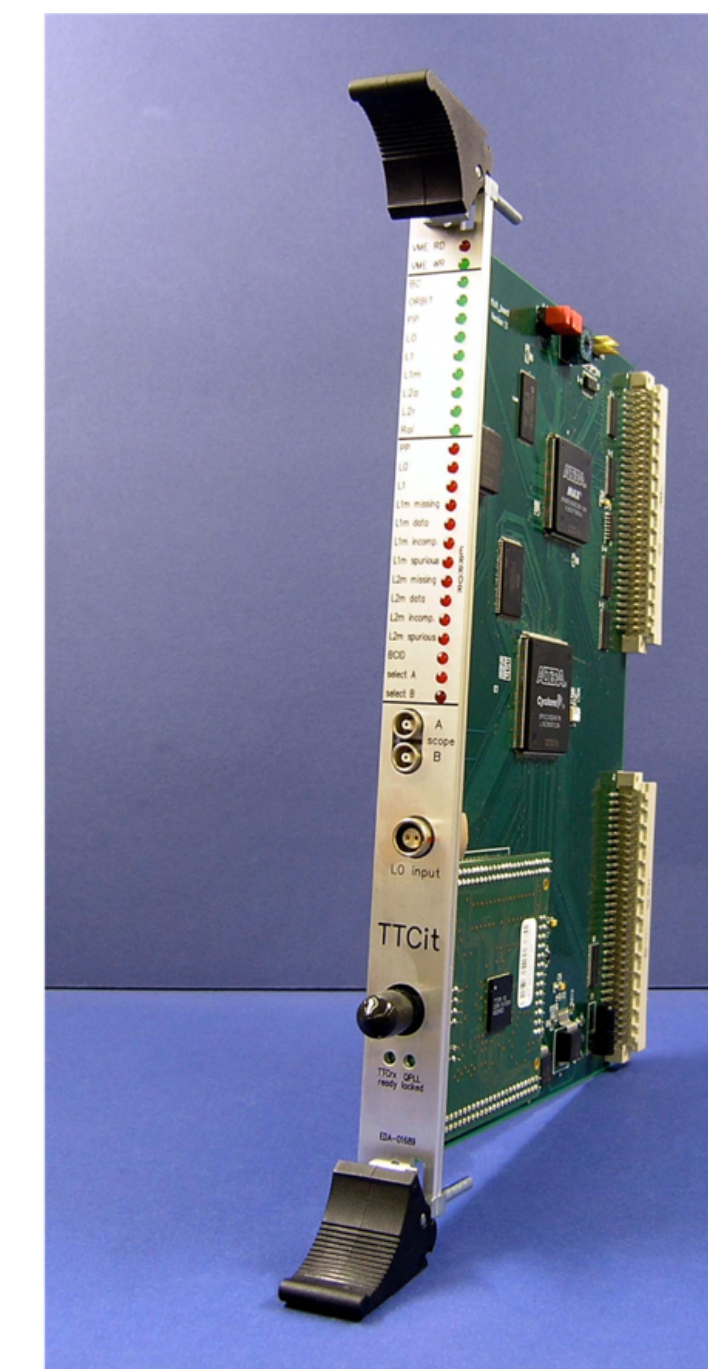
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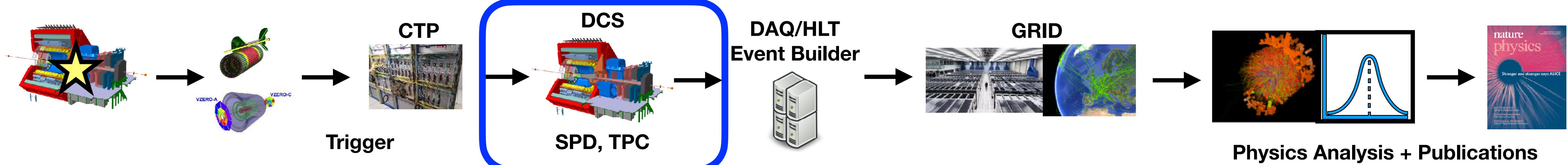


Slovak contribution to **Trigger system**:

- very close collaboration with University of Birmingham (UoB)
- Trigger Timing and Control interface test (TTCit) board for Run1 (IEP SAS)
- development, production, and testing of mezzanine FMC-CTP card for Run3 and debugging a new L0 board (IEP SAS)
- on-line luminosity measurement at ALICE interaction point (using trigger data) in Run1, Run2 and Run3 (IEP SAS)
- implementation of trigger software into ALICE analysis framework for Run2 (UoB + UPJŠ)
- monitoring (quality assurance) of trigger system for Run2 and Run3 (UPJŠ)

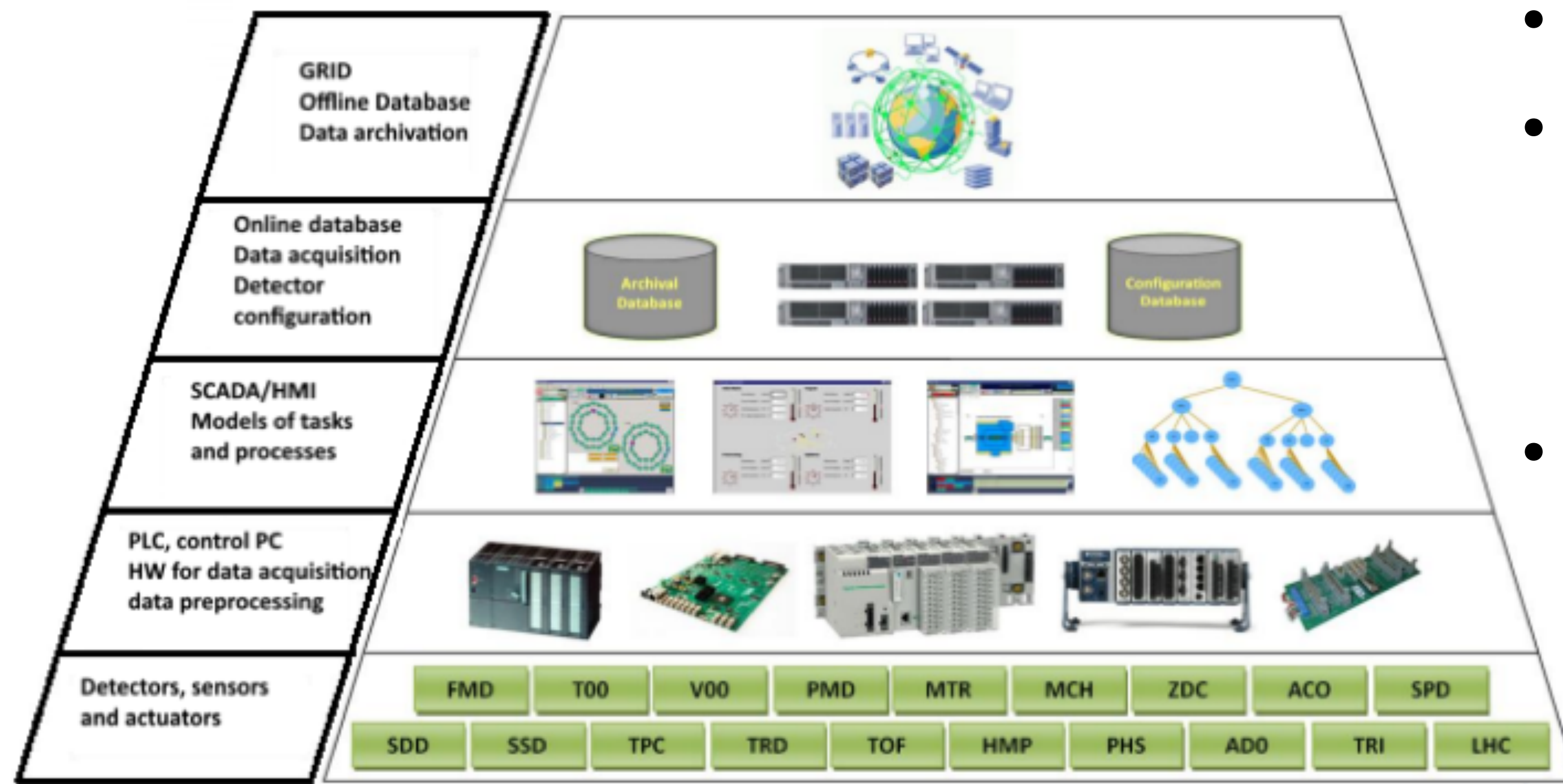


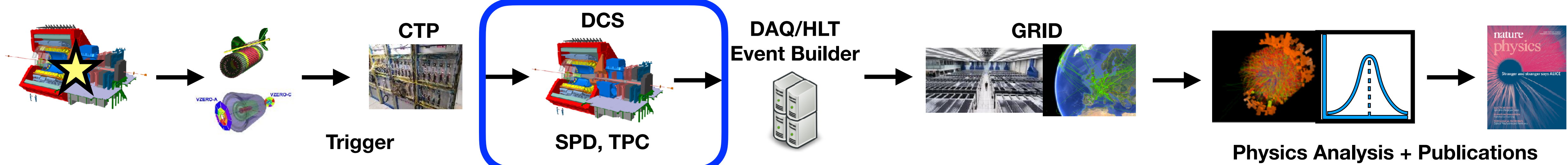
TTCit board



Slovak contribution to **Detector Control System:**

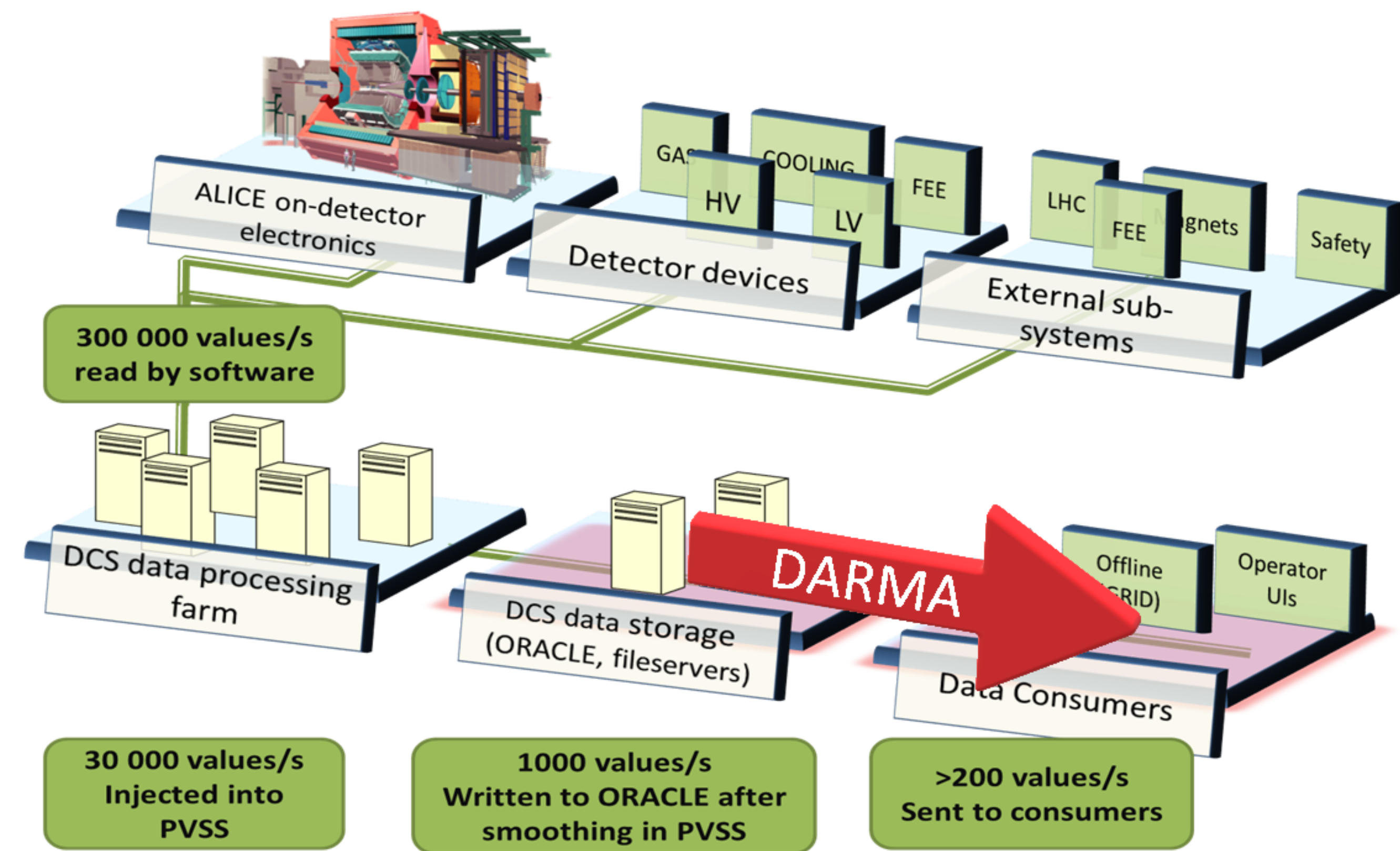
- design, development, testing for Run1 and Run2 (FMFI UK)
- design and running of computer farm for Run1 (FMFI UK)
- development of DARMA (DCS archive manager) (TUKE):
 - remote access to the offline data of the ALICE DCS
 - web application accessible on the CERN network
- development of FRED - Scalable Framework for Detector Control & Monitoring (TUKE):
 - originally developed for DCS of the ITS detector, now widely used by other ALICE detectors
 - stable detector control and fast monitoring

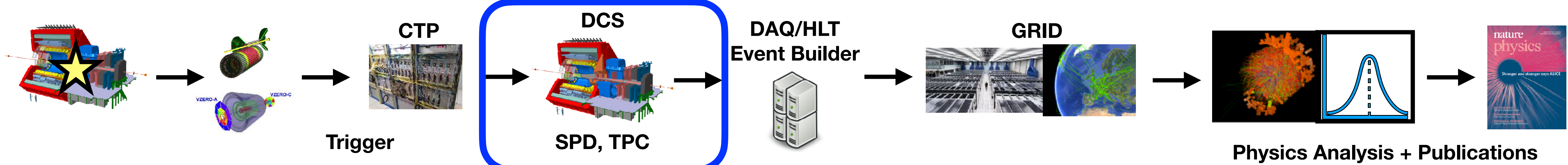




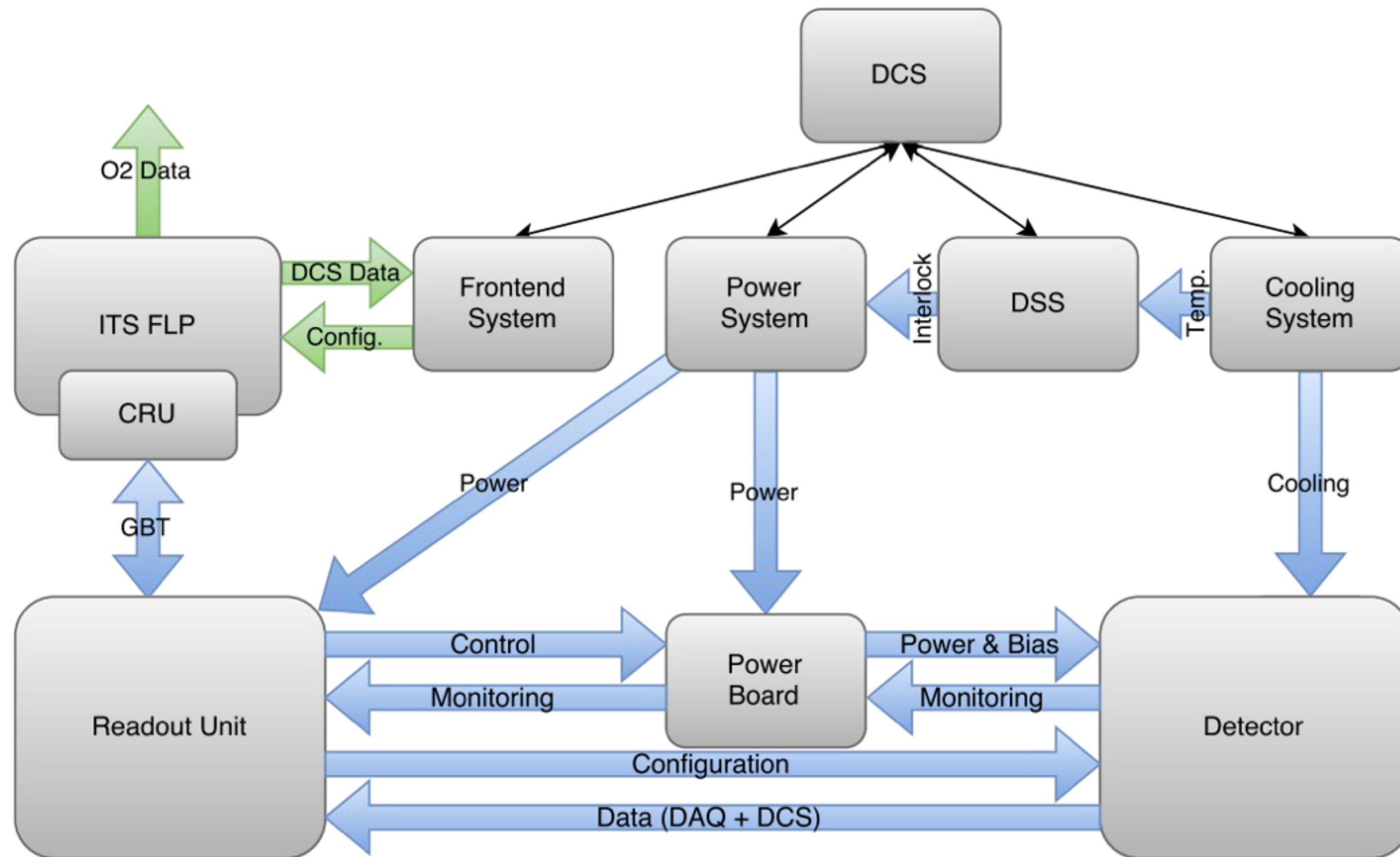
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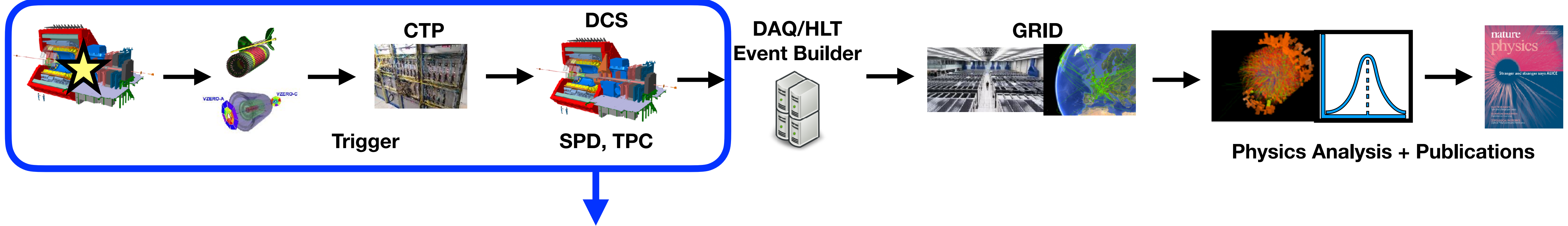




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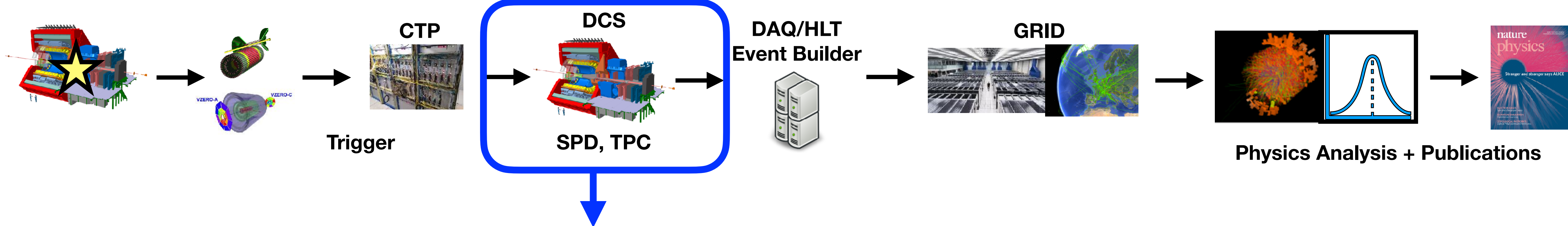
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Slovak contribution to **Data Taking**:

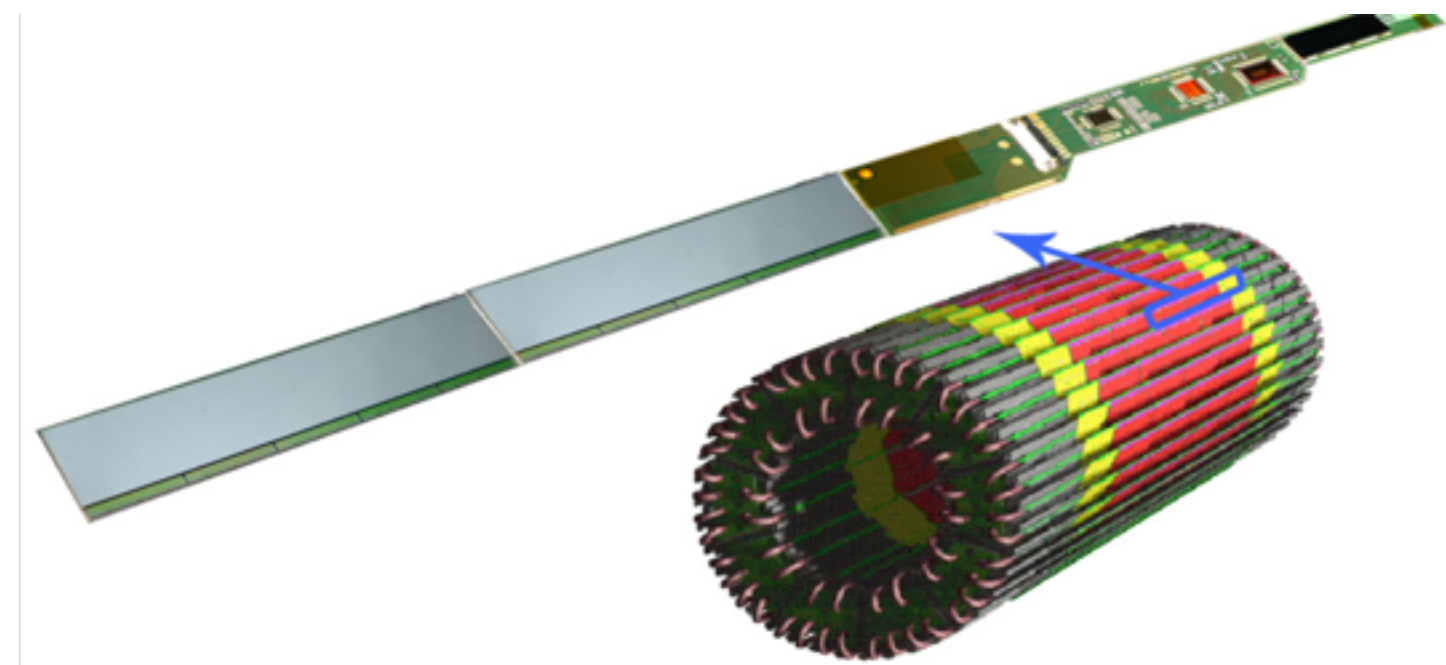
- Run managers for Run1, Run2, Run3 (FMFI UK)
- Experienced DCS shifters for Run1, Run2 and Run3 (IEP SAS)
- On-call CTP experts for Run2 and Run3 (UPJŠ)



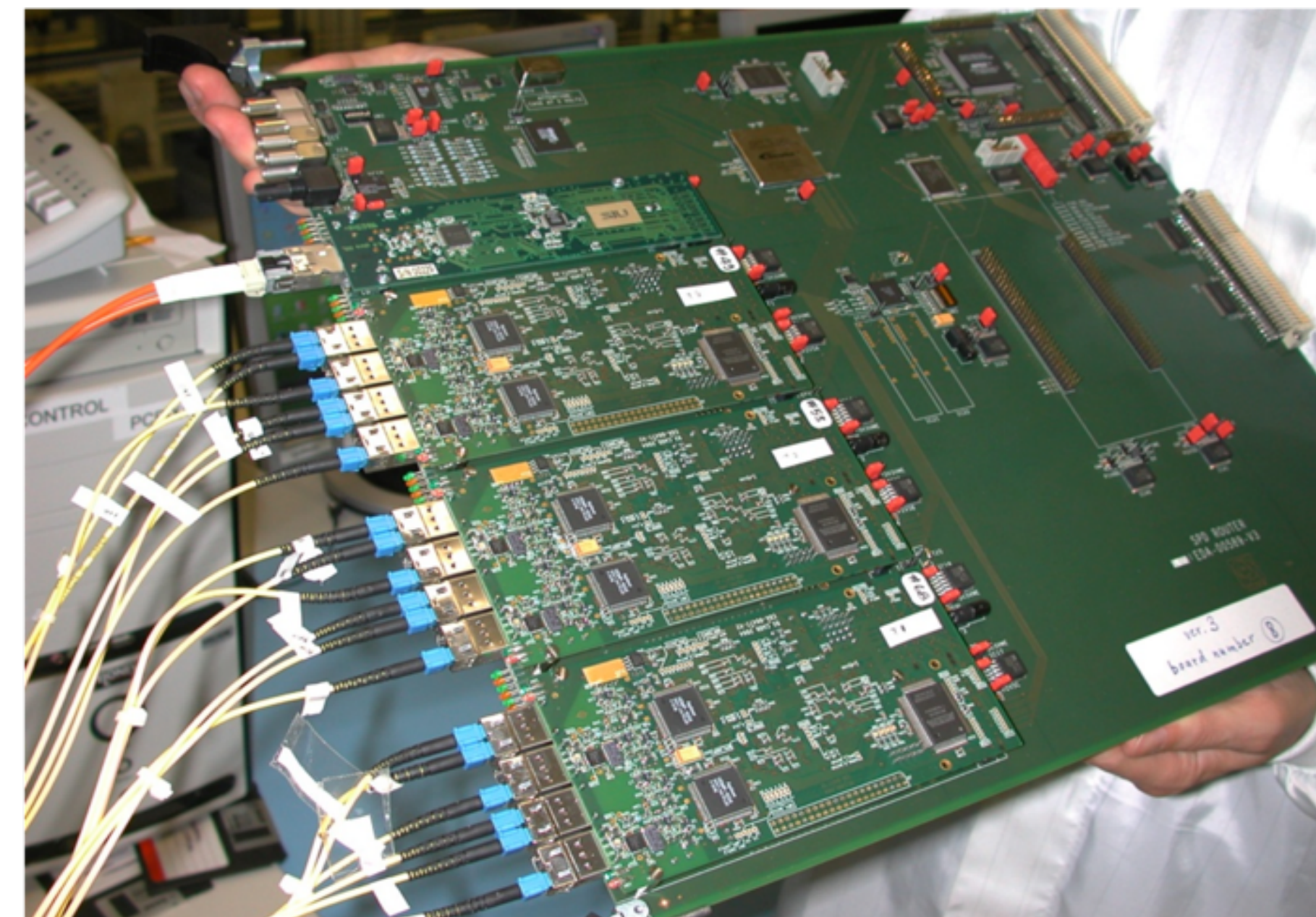


Slovak contribution to Silicon Pixel Detector:

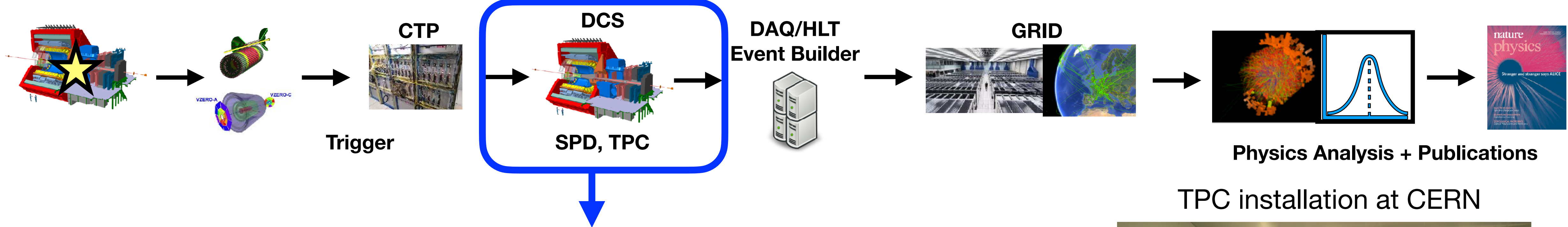
- development, installation, running (FMFI UK)
- readout electronics - SPD router - interfaces to CTP, DCS, SPD and DAQ, 20 boards installed in ALICE (IEP SAS)
- in Run3 - completely new DCS for ITS-2 (TUKE)



SPD consists of 120 half staves



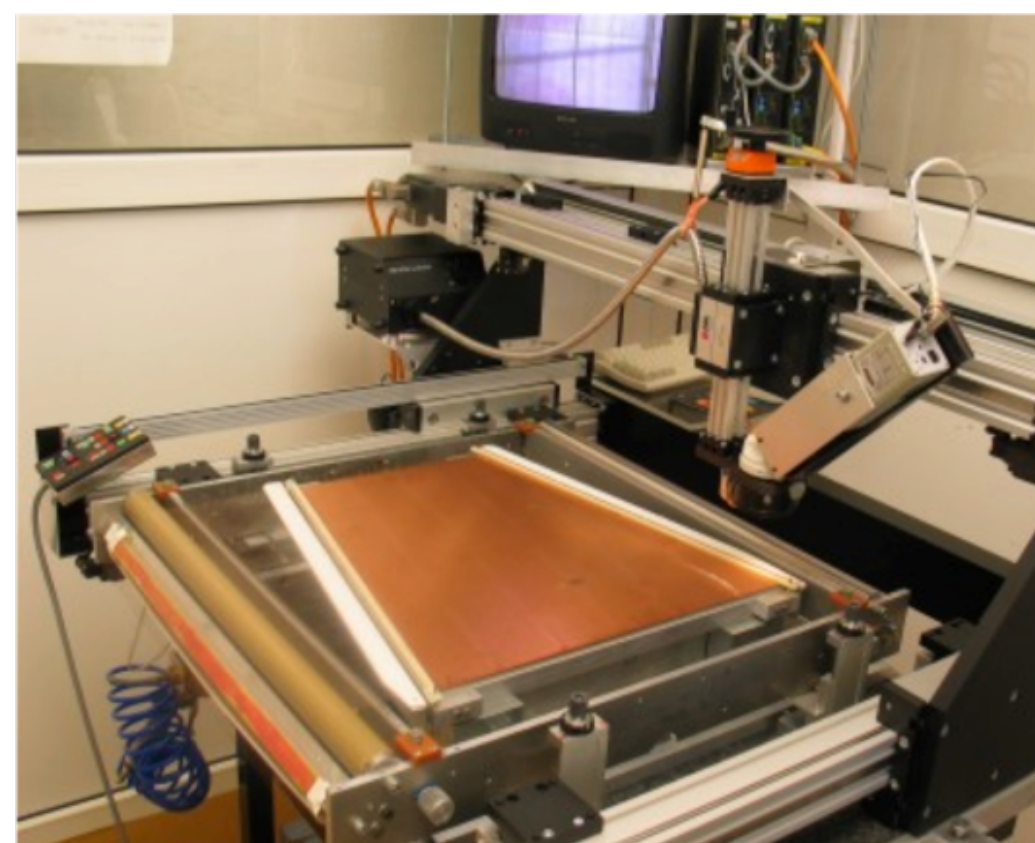
SPD router connected to 6 half staves - 20 boards needed



Slovak contribution to **Time Projection Chamber:**

- 26 Inner Readout Chambers (used in Run1 and Run2) produced in Bratislava (FMFI UK)
- in Run3: readout MWPC replaced with GEM chambers - R&D in Bratislava, fast gases, drift and discharge measurements (FMFI UK)

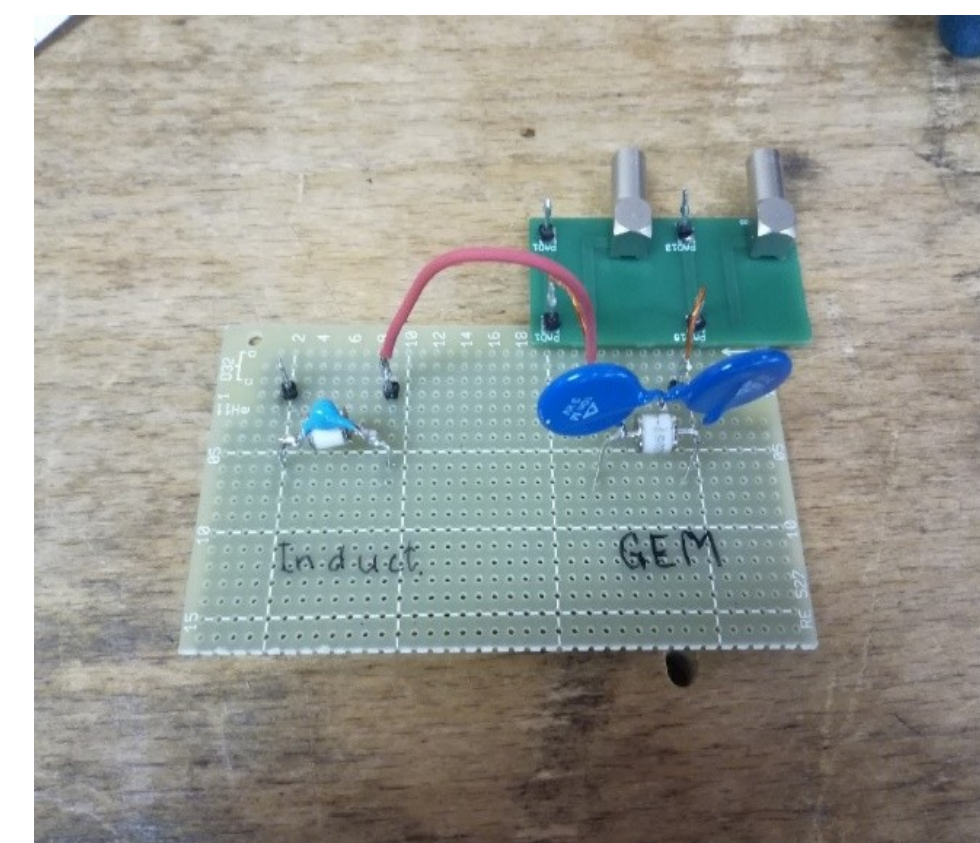
TPC installation at CERN



IROC production



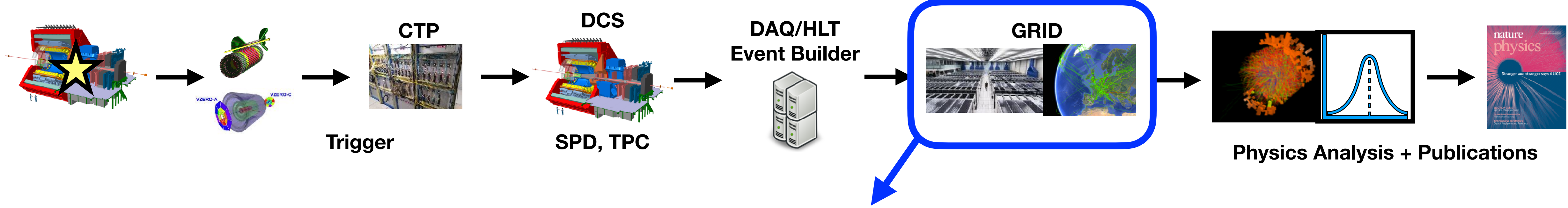
Small TPC for drift measurement



Global discharge tube

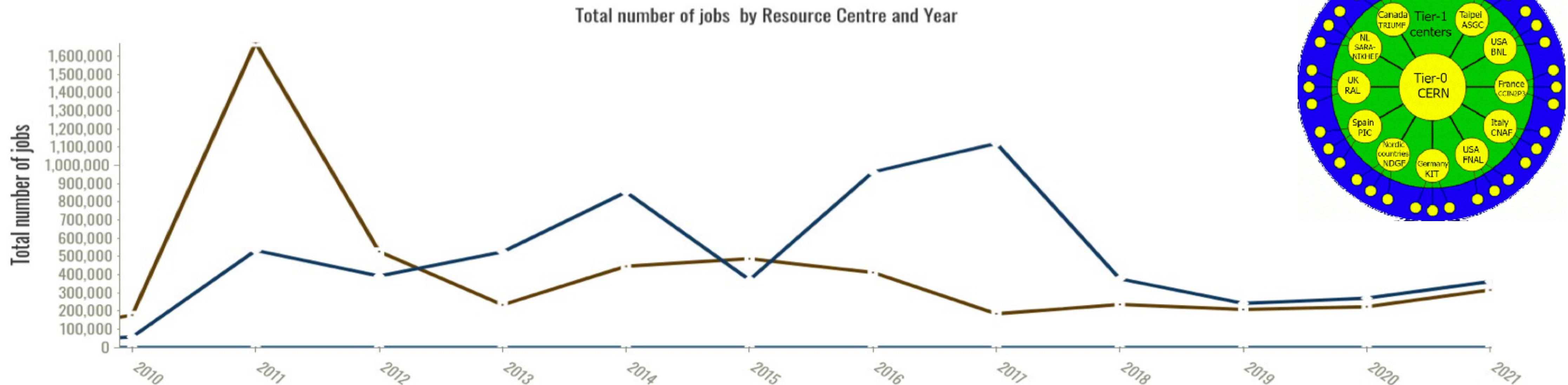


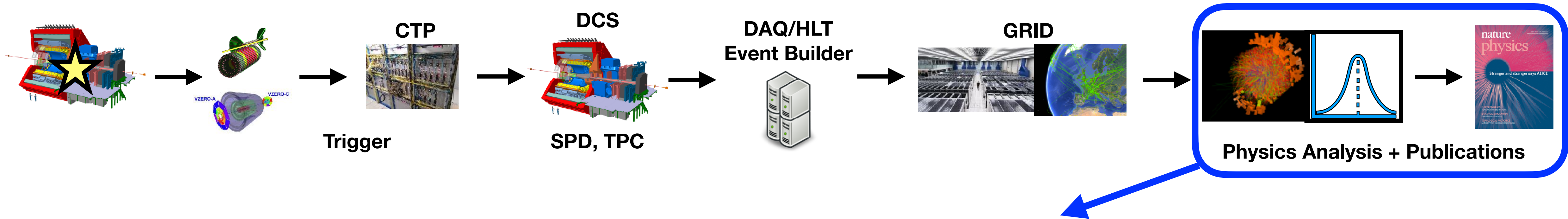
Laser Detector Laboratory



Slovak contribution to **GRID Computing**:

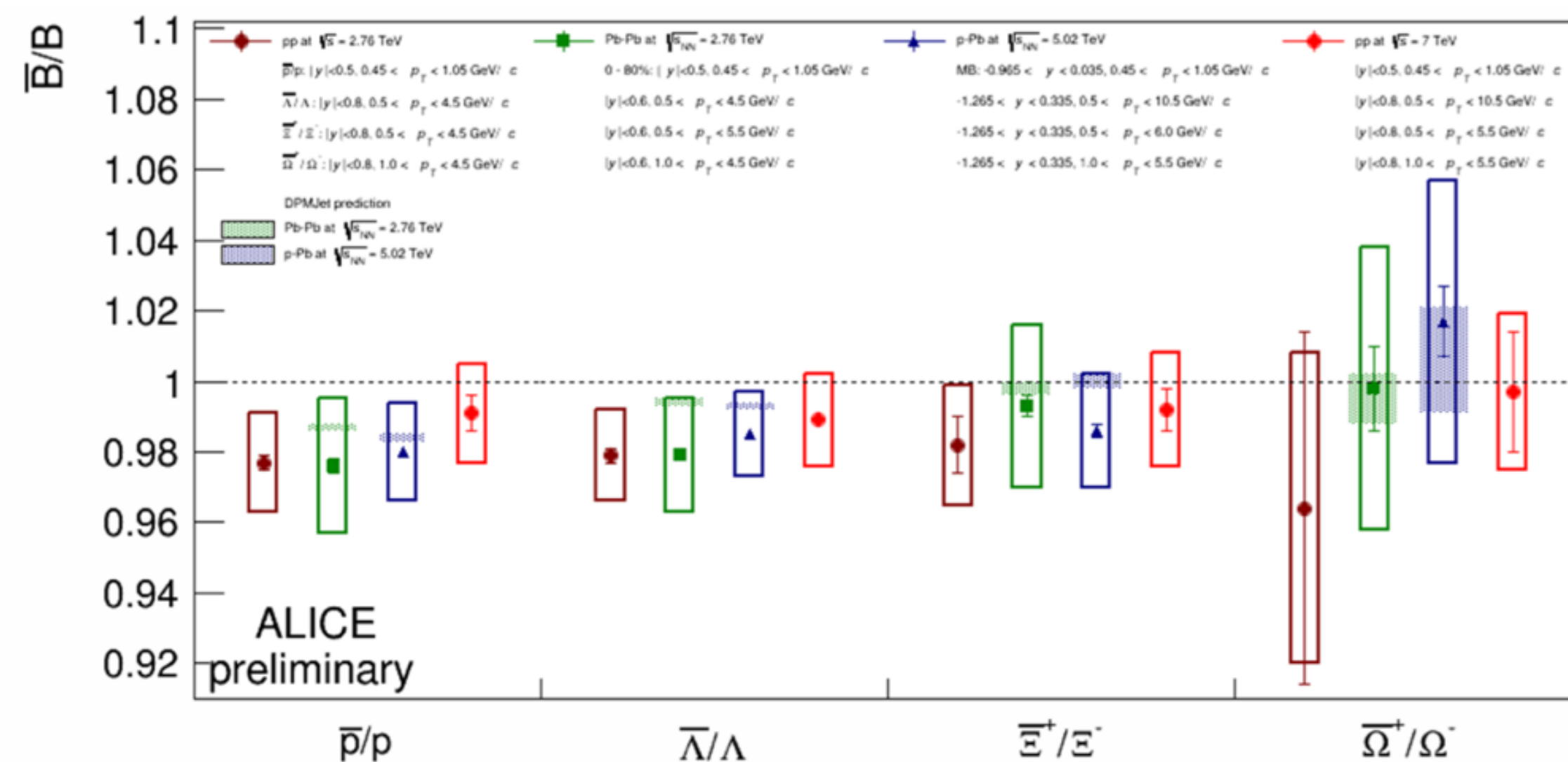
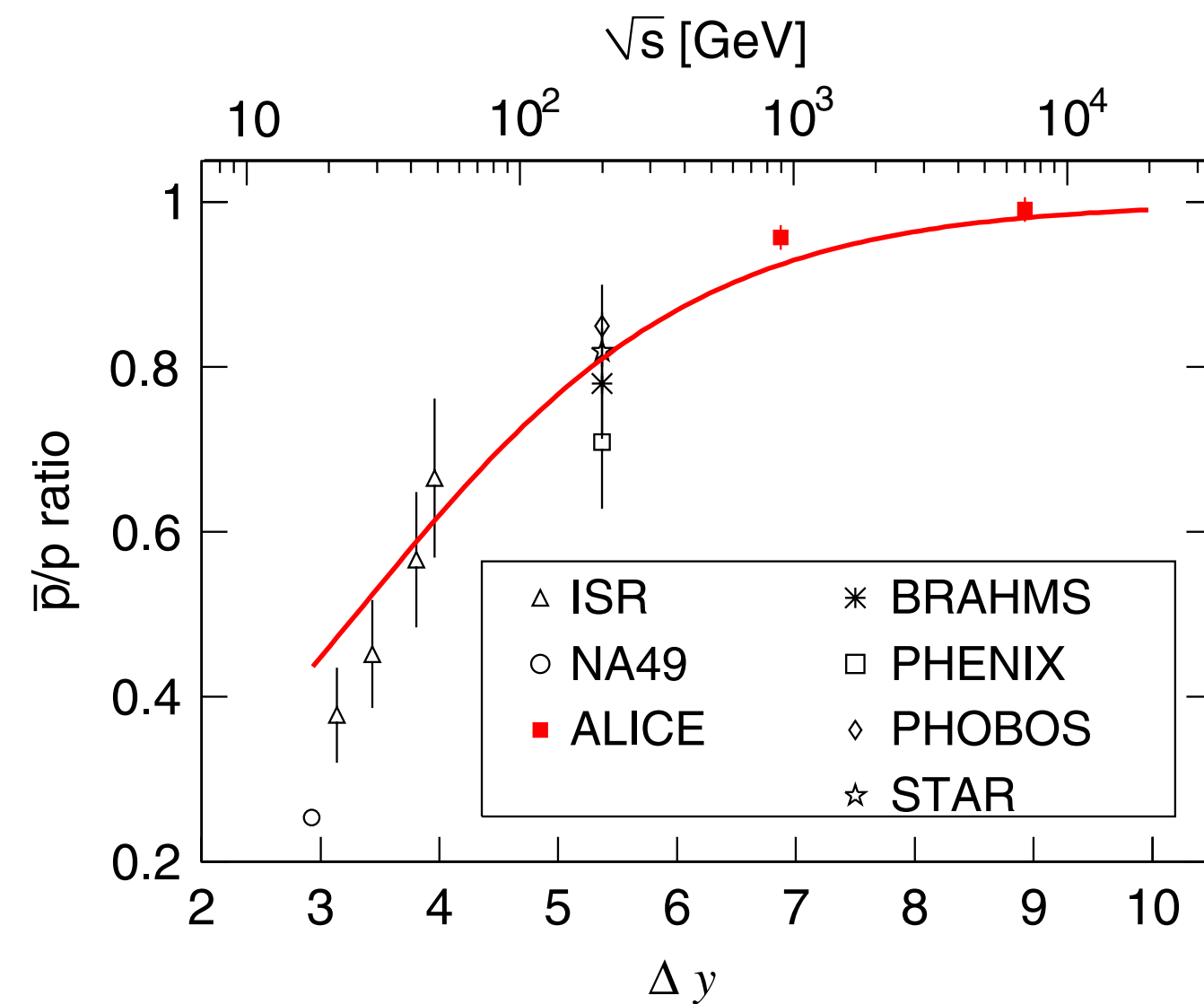
- Two Tier-2 centres in FMFI UK and IEP SAS used in Run1, Run2 and Run3: 5PB and 2000 CPUs, ~1M jobs/year
- In Run1: SKAF (Slovak Košice Analysis Facility) and CAF (CERN Analysis Facility) - clusters running PROOF (Parallel ROOT Facility) - distributed system suitable for smaller datasets than at GRID (IEP SAS)



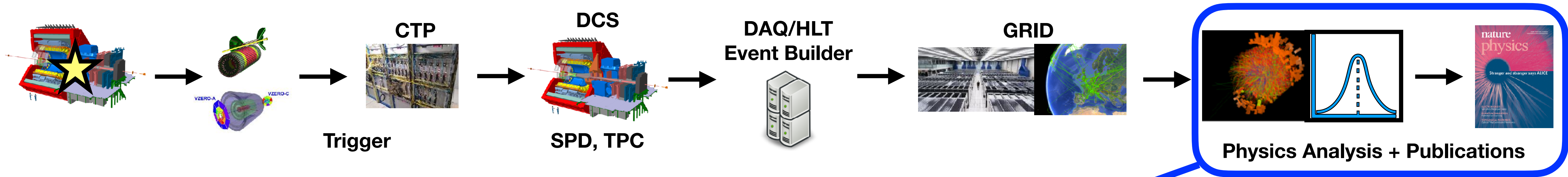


Slovak contribution to **Physics:**

- antiproton to proton ratio (or antibaryon to baryon ratio) - how the baryon number is transported (FMFI UK)

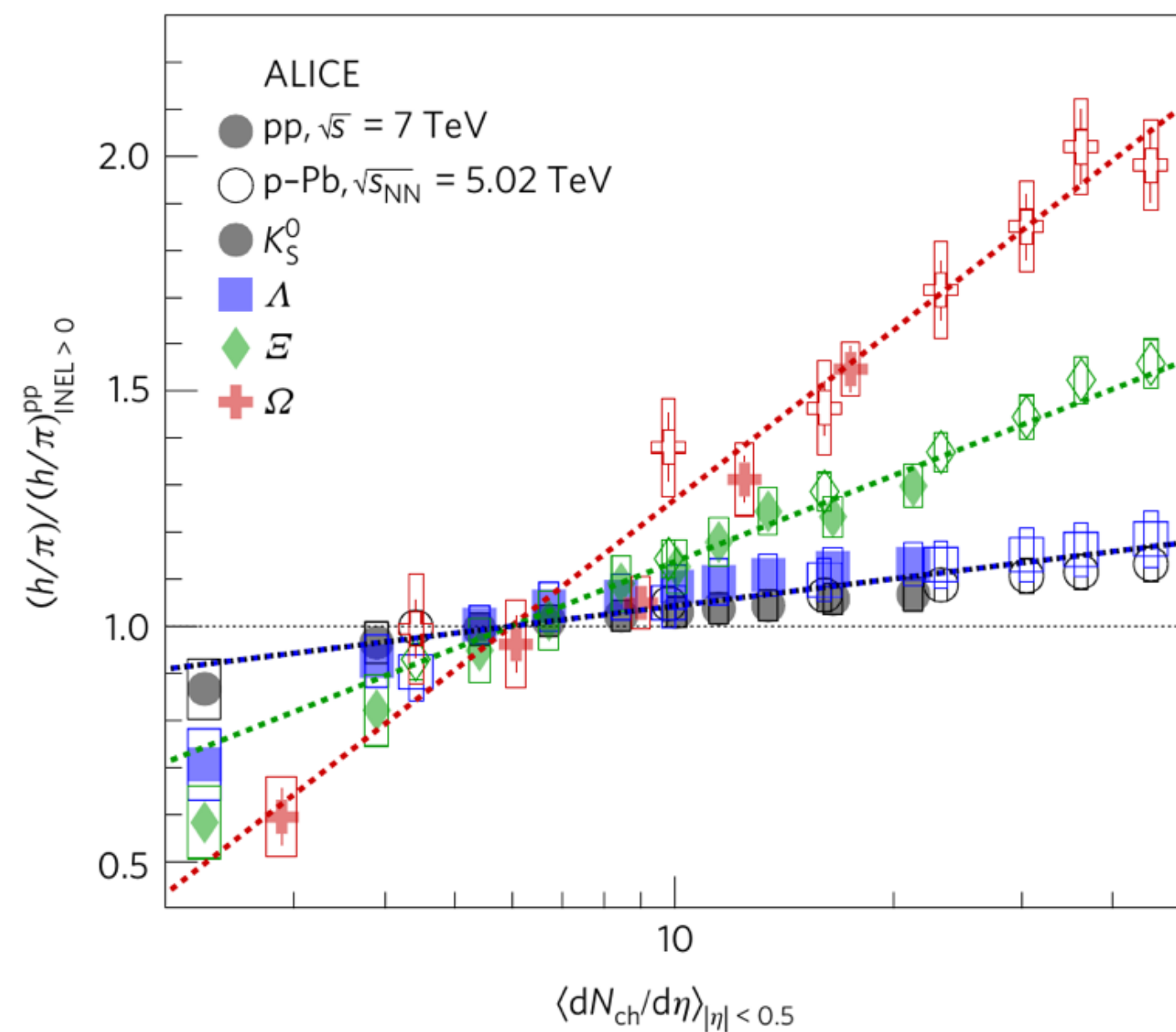


Phys. Rev. Lett. 105, 072002 (2010)

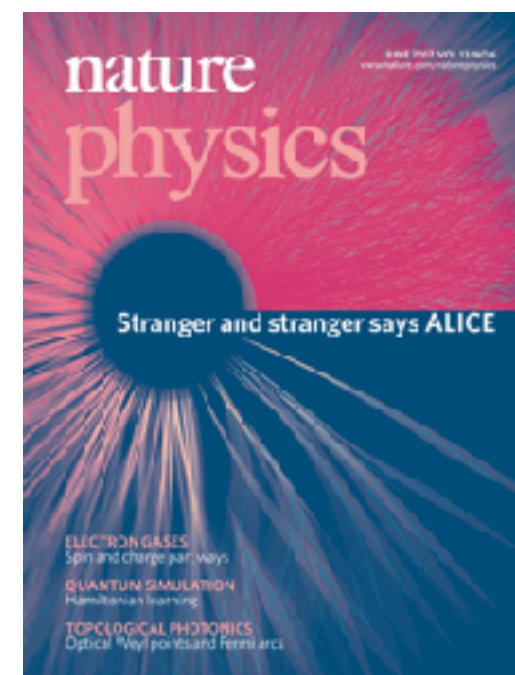


Slovak contribution to **Physics:**

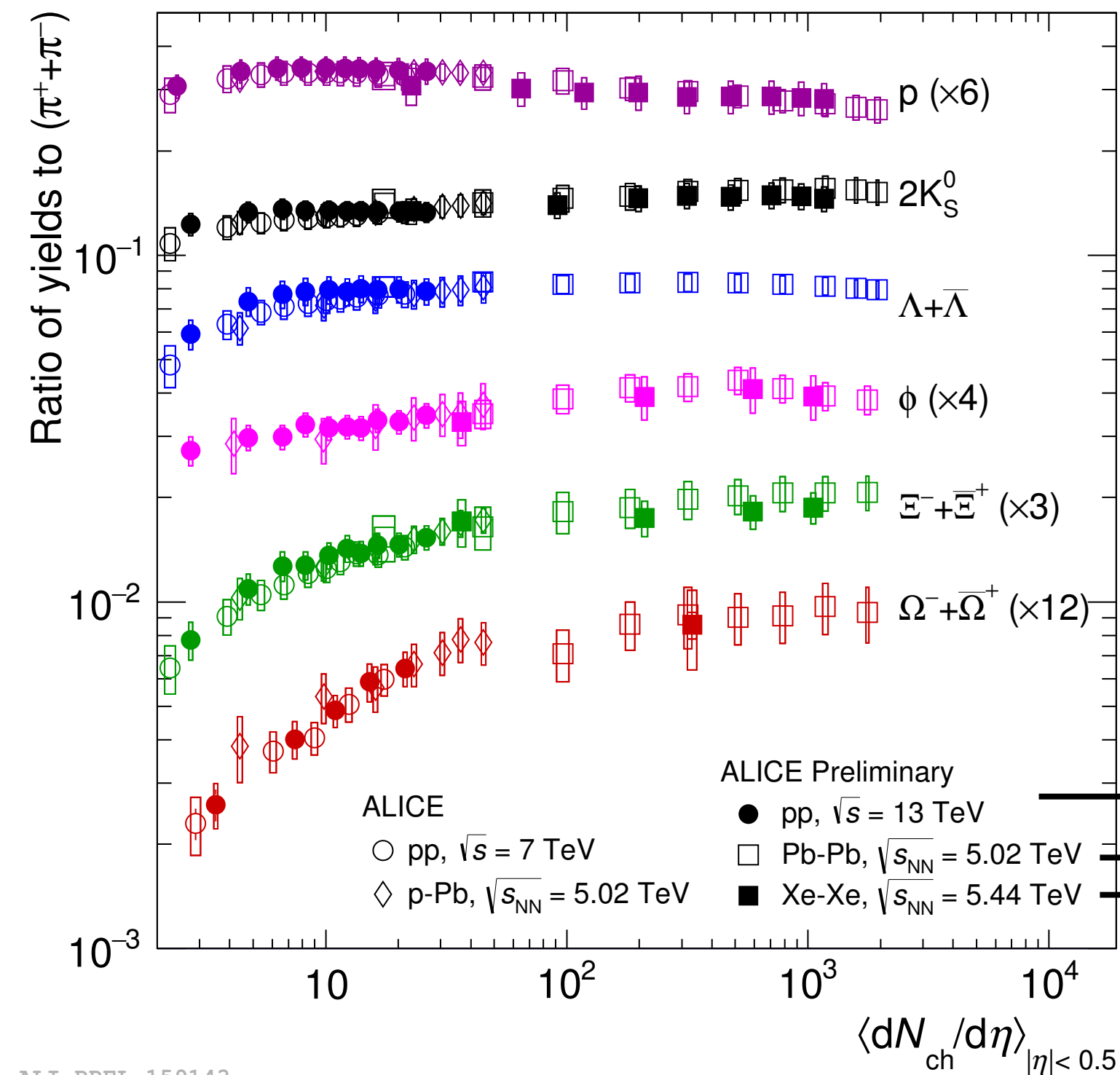
- strange particles production in various colliding systems - important to understand the hadron production mechanism (UPJŠ, IEP SAS and FMFI UK)
- coordination of Strangeness Physics Analysis Group (UPJŠ)



Upgrade of

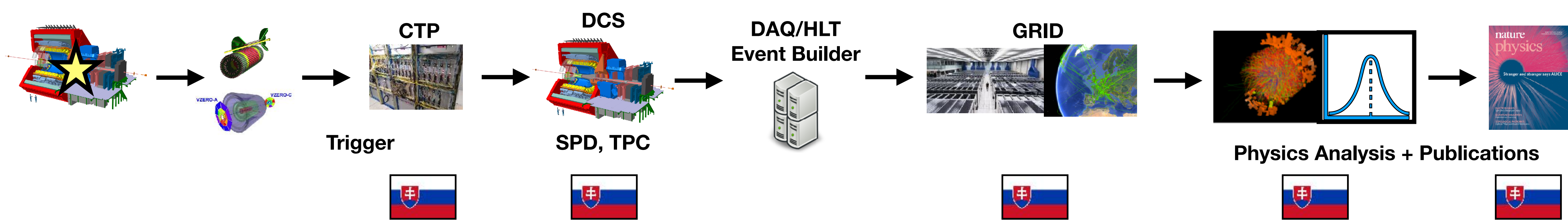


in



IEP SAS
UPJŠ
FMFI UK

Eur. Phys. J. C 81 256 (2021)



Summary

- Slovakia has been playing an important role in ALICE story due to involvement in crucial parts:
 - Trigger system
 - DCS (Detector Control System)
 - SPD (Silicon Pixel Detector)
 - TPC (Time Projection Chamber)
 - Grid (two Tier-2 centres)
 - Physics (mostly strange particle production)
- For the ongoing Run3 and next Run4 Slovakia continues as a reliable member of the ALICE family.

