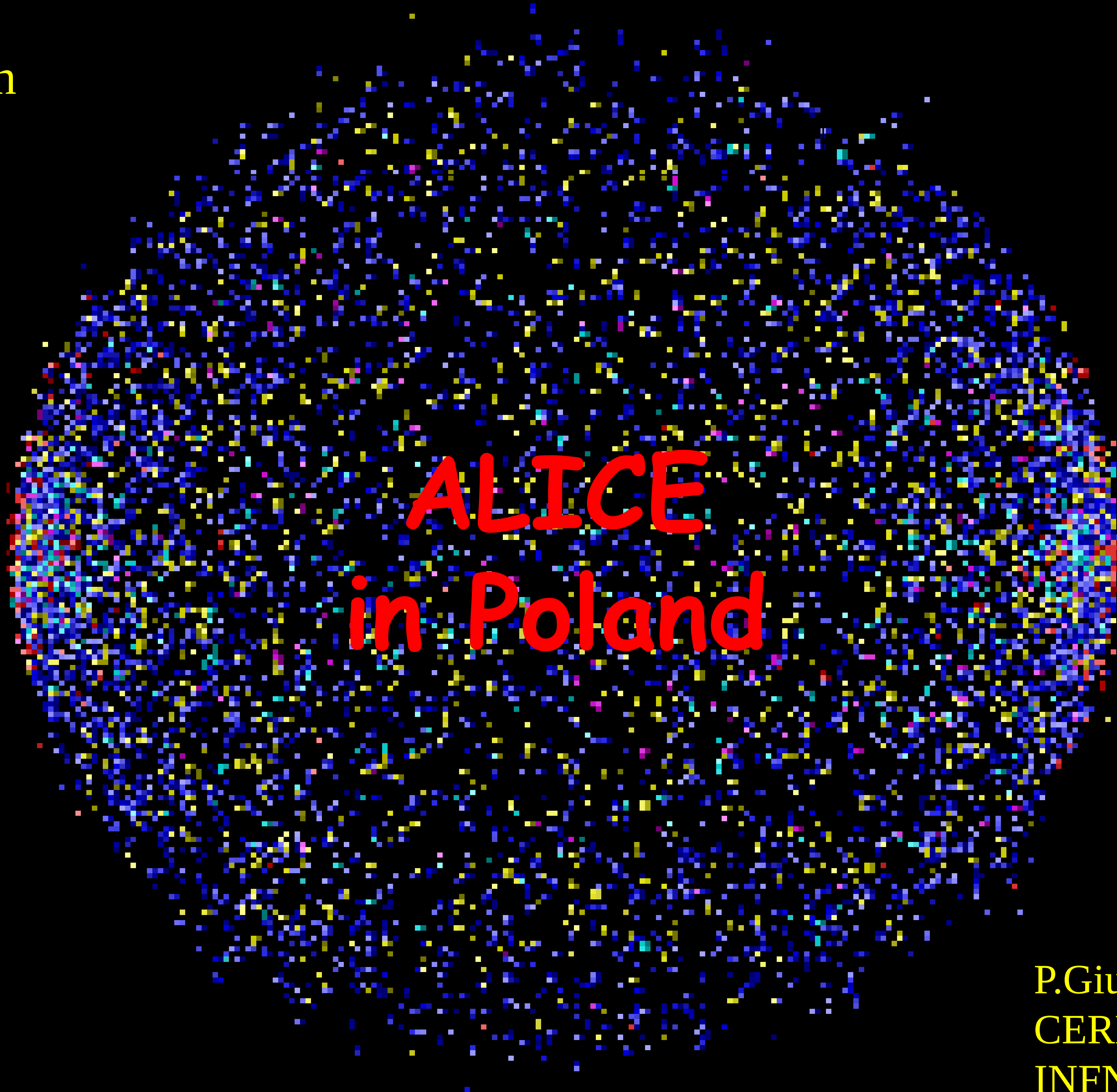
WUT
March 11th
2014

ALICE in Poland

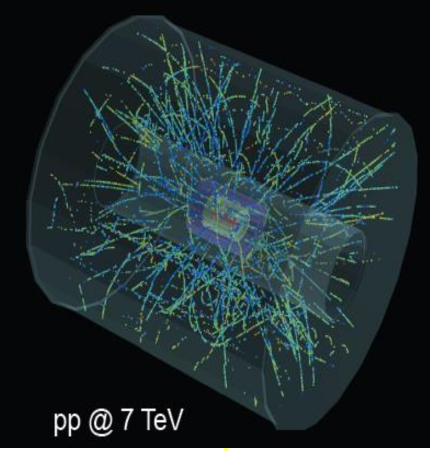


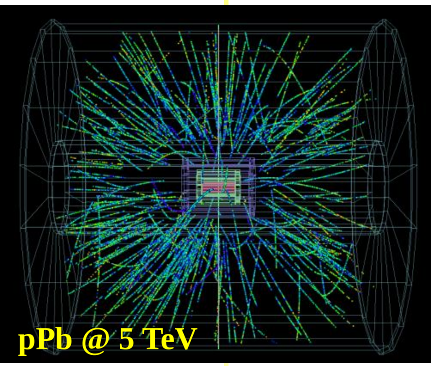
P.Giubellino
CERN and
INFN Torino

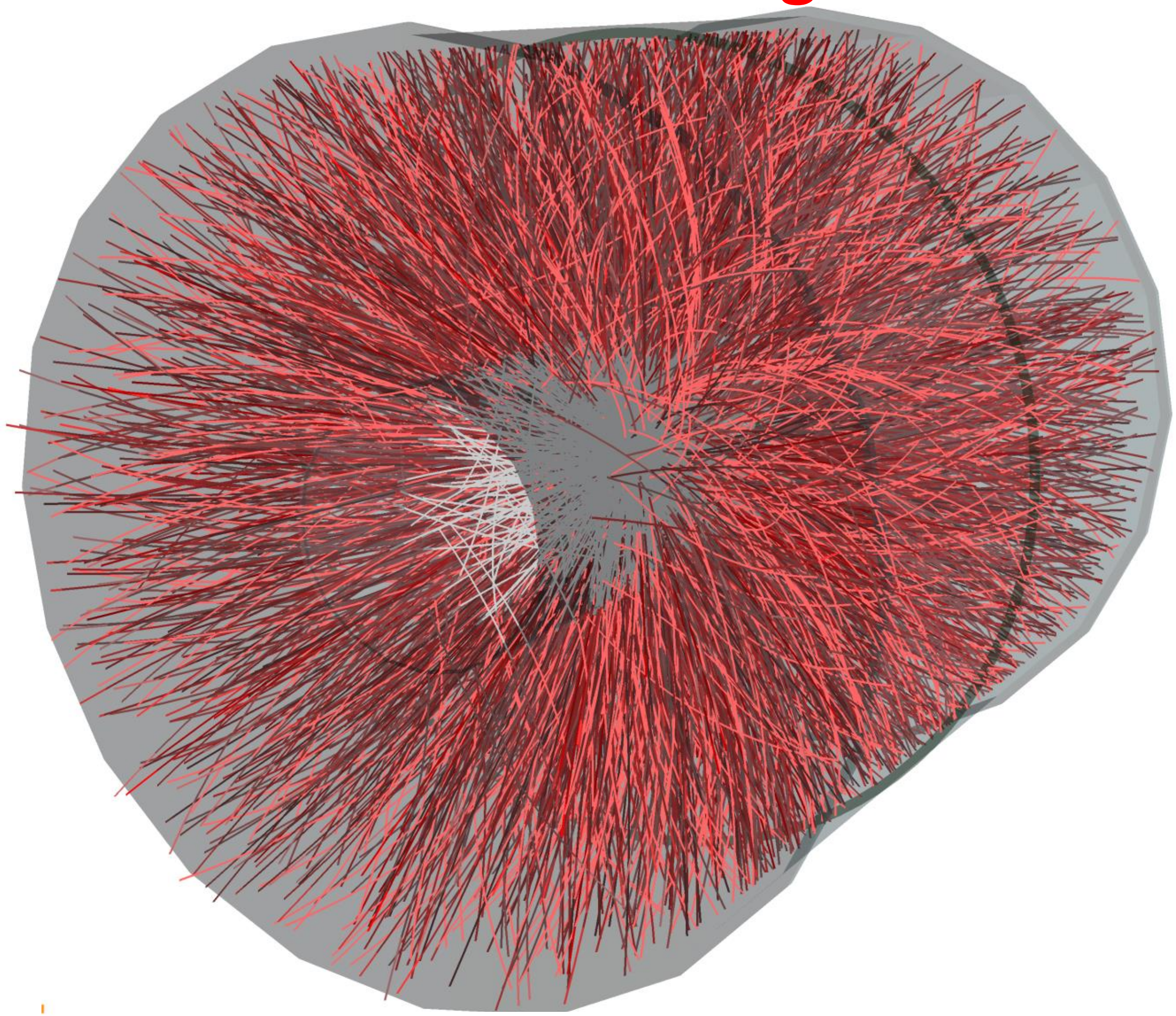
Remembering a dear friend, and a great colleague

Viktor Peryt

Collisions of Nuclei in the LHC:
The world's most energetic collisions





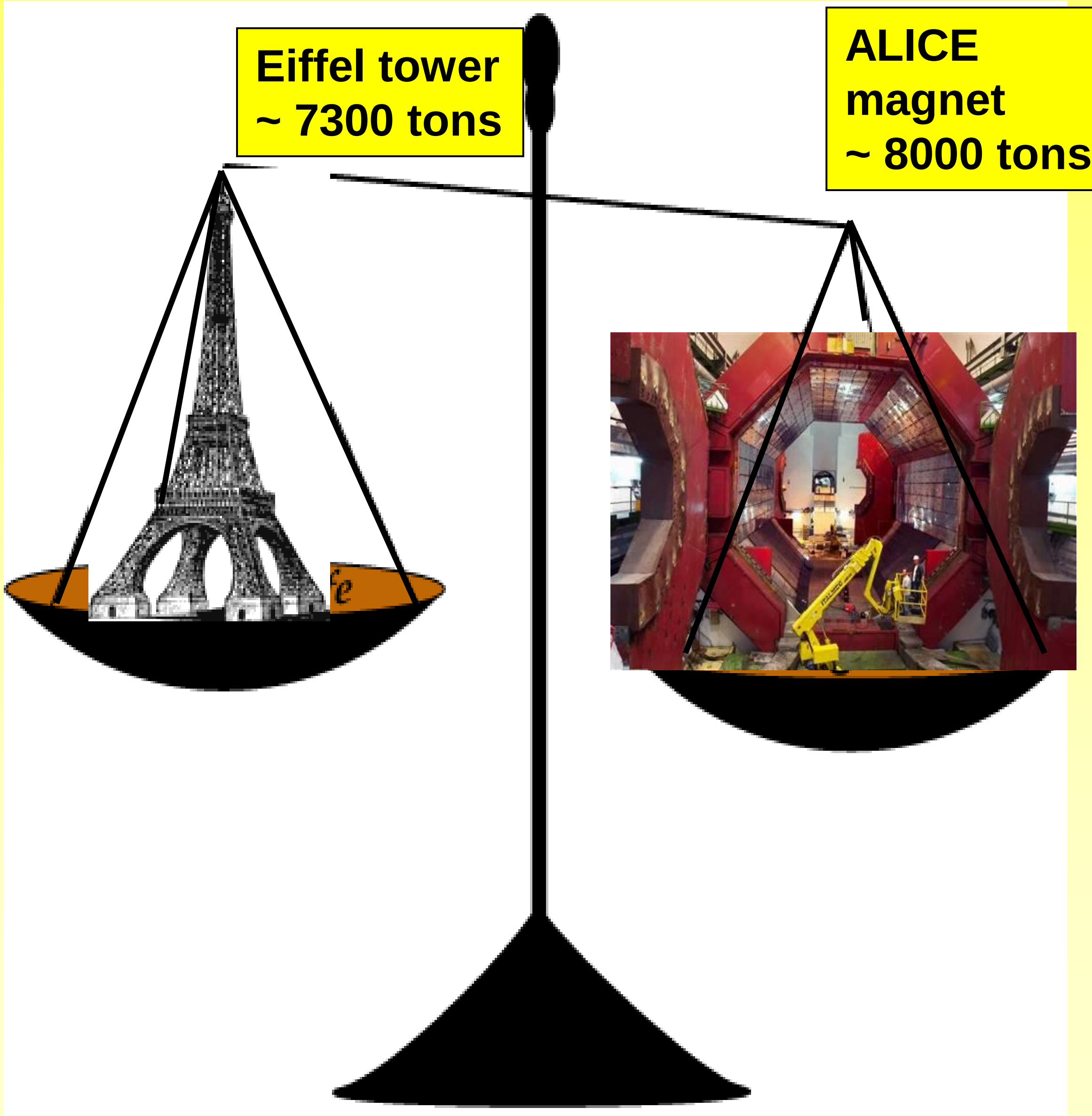


ALICE

Very Complicated!

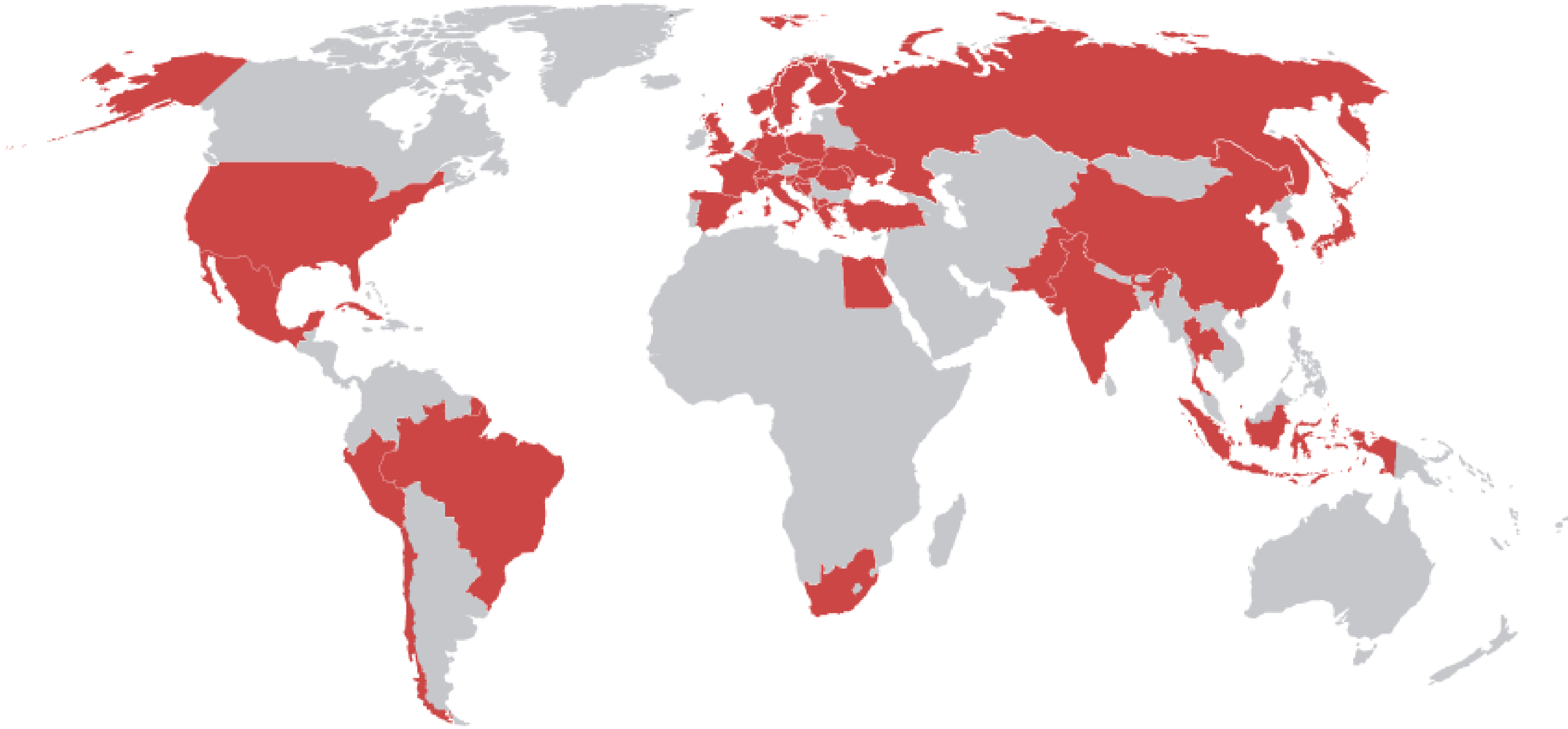
Nuclear Physics has changed…

- Nuclear Physics experiments are nowadays world-wide high-tech projects of extreme complexity, which develop over decades!
- Experimental approaches common with HEP



Carried by worldwide collaborations

- ALICE today



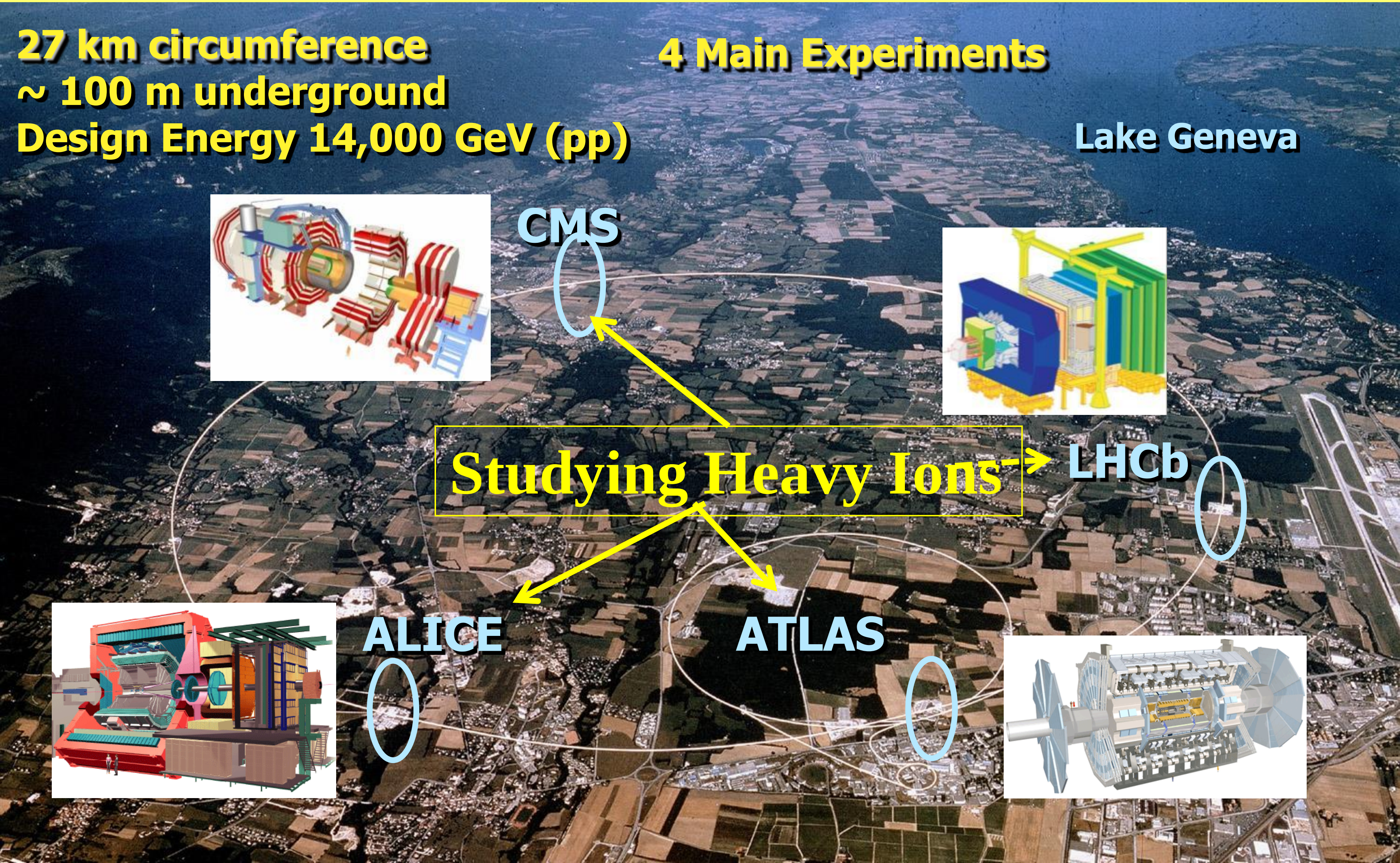
- **37 COUNTRIES – 141 INSTITUTES – 160’653 KCHF CAPITAL COST**

Even the “simplest” element requires
wo

A TRUE “GLOCAL” SYSTEM

- The detectors are designed and built “at home”, in the individual participating institutions, which bring in their know-how, scientific and technical skills, the local industry… but with a continuous exchange with the others, which makes it possible for all the individual elements to fit together.
- The groups who have developed a specific element follow it up in the test, commissioning and integration in the experiment, and later in its operation at CERN
- The data collected are spread worldwide for processing and final analysis, which is carried again in the home institutions, although the analysis groups meet typically on a weekly basis (via internet)
- All decisions on the technical choices, on operations and on the analysis are taken collectively by the collaboration

Using the World's most powerful accelerator: the Large Hadron Collider LHC

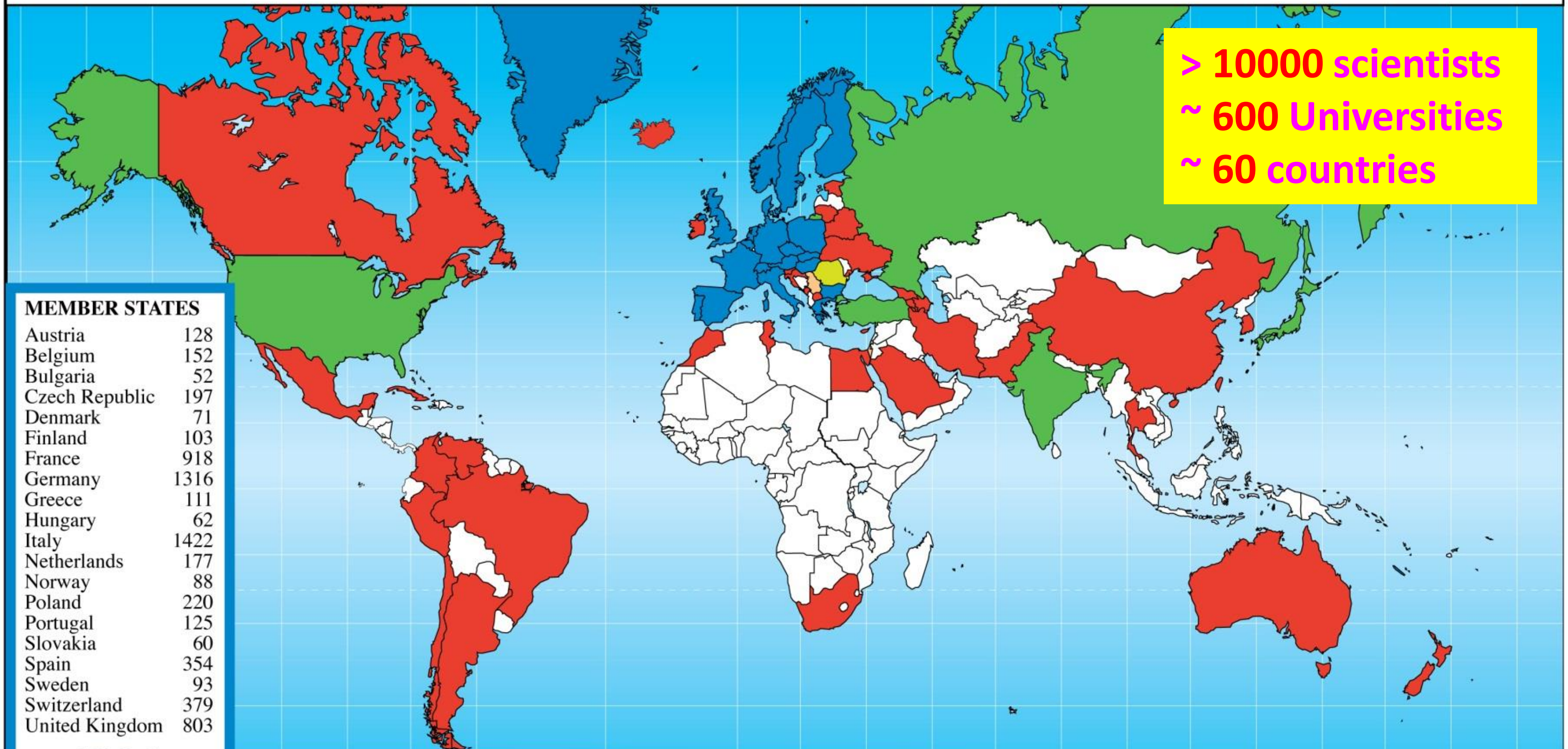


What is CERN?

- CERN: European Organization for Nuclear Research
  - World's largest laboratory for fundamental research in particle physics
    - Geneva, Switzerland (but ~ ½ of it located in France)
  - European inter-governmental organization (20 Member States)
    - ~ 2500 Staff, Budget ~ 1 billion CHF/year (contribution by MS ~ to GNP)
      - administration, logistics, engineers, applied scientists, technicians, ~ 100 researchers
- Mission
  - Push forward the frontiers of knowledge
  - Develop new technologies for accelerators and detectors
  - Train scientists and engineers of tomorrow
  - Unite people from different countries and cultures

… reaching the entire world

Distribution of All CERN Users by Location of Institute on 14 January 2013



MEMBER STATES

Austria	128
Belgium	152
Bulgaria	52
Czech Republic	197
Denmark	71
Finland	103
France	918
Germany	1316
Greece	111
Hungary	62
Italy	1422
Netherlands	177
Norway	88
Poland	220
Portugal	125
Slovakia	60
Spain	354
Sweden	93
Switzerland	379
United Kingdom	803

6831

OBSERVERS

India	146
Japan	238
Russia	883
Turkey	94
USA	1757

3118

CANDIDATE FOR ACCESSION

Romania	88

ASSOCIATE MEMBER IN THE PRE-STAGE TO MEMBERSHIP

Israel	63
Serbia	31

OTHERS

Argentina	19
Armenia	15
Australia	32
Azerbaijan	2
Belarus	22
Brazil	107
Canada	168
Chile	7
China	114
China (Taipei)	69
Colombia	10
Croatia	24
Cuba	3
Cyprus	7
Egypt	11
Estonia	17
Georgia	10
Iceland	4
Iran	23
Ireland	8
Korea	96
Lithuania	13
Malta	1
Mexico	41
Montenegro	1
Morocco	10
New Zealand	9
Pakistan	22
Peru	2
Saudi Arabia	3
Slovenia	30
South Africa	25
Thailand	5
T.F.Y.R.O.M.	2
Tunisia	1
Ukraine	25
Venezuela	1

959

What is CERN impact on society?

- Disclaimer:
  - Science advances are moved by the fundamental human curiosity for the unknown… applications have always existed but do not replace fundamental research: ***the lightbulb was not invented by progressively improving candles!***
  - Often the most relevant applications come unexpected, like the **www**
- CERN in general and LHC in particular have a huge impact
  - industrial progress trough competitive international high tech tenders
  - Development of ad-hoc technologies which later find applications in other fields
  - **Training of young scientists and engineers both in technology and in international cooperation**
    - Many programs:
      - Student Visits
      - Summer Studens
      - Technical and Doctoral Students
      - Teachers Programs (for High-school teachers)

Examples of technologies developed at CERN

WWW, of course! But there are many more....

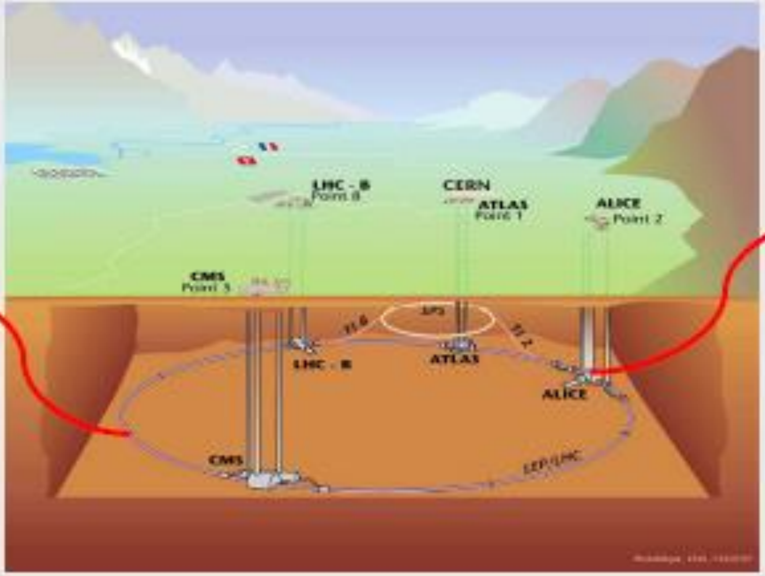
Tim Berners-Lee, CERN March 1989, May 1990

Frank Beck and Bent Stumpe, engineers from CERN, developed a transparent touch screen in the early 1970s. it was manufactured by CERN and put to use in 1973

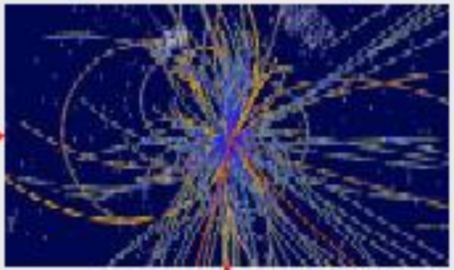
CERN technologies

- 3 key technologies:

Accelerating particle beams



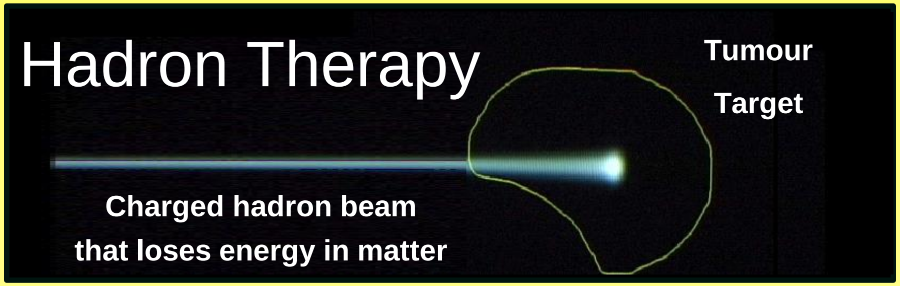
Detecting particles



Large-scale computing (Grid)

Medical applications: few examples

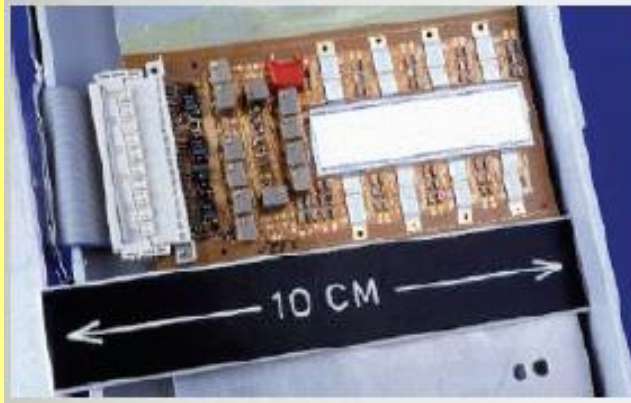
Particle accelerators



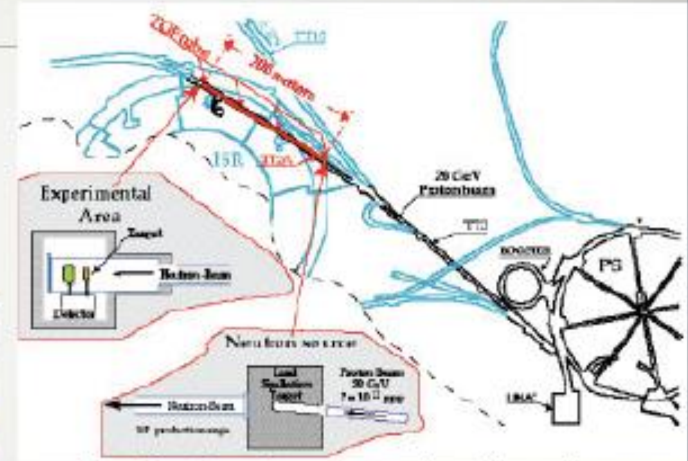
There are today 17000 accelerators in the world of which just 100 used for particle physics research, the others are used for:

- **Cancer therapy**
- **semiconductor industry**
- **electron beam welding and cutting**
- **sterilization – food, medical**
- **radioisotope production**
- **non-destructive testing**
- **incineration of nuclear waste**
- **source of neutrons**
- **source of synchrotron radiation**
- **biology**
- **solid state physics**

… and many more …

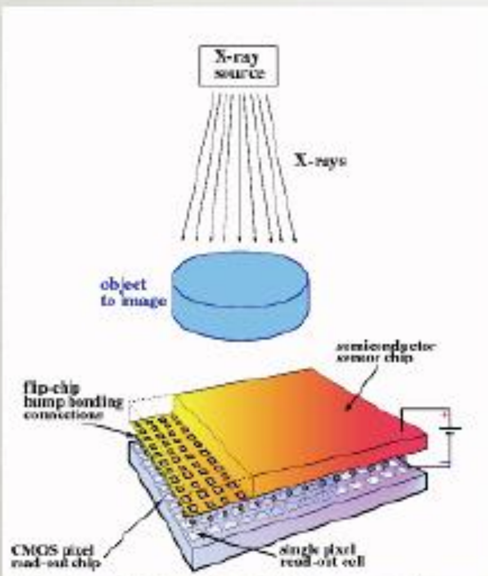


Silicon detector for a Compton camera in nuclear medical imaging

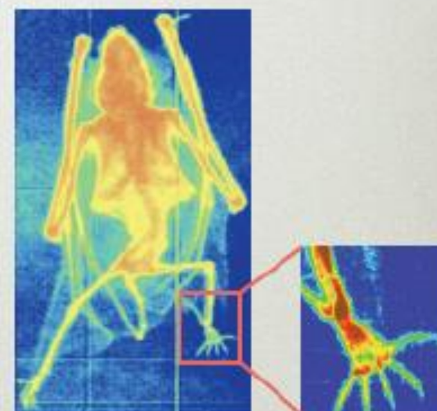


Radio-isotope production for medical applications

Thin films by sputtering or evaporation



Medipix: Medical X-ray diagnosis with contrast enhancement and dose reduction



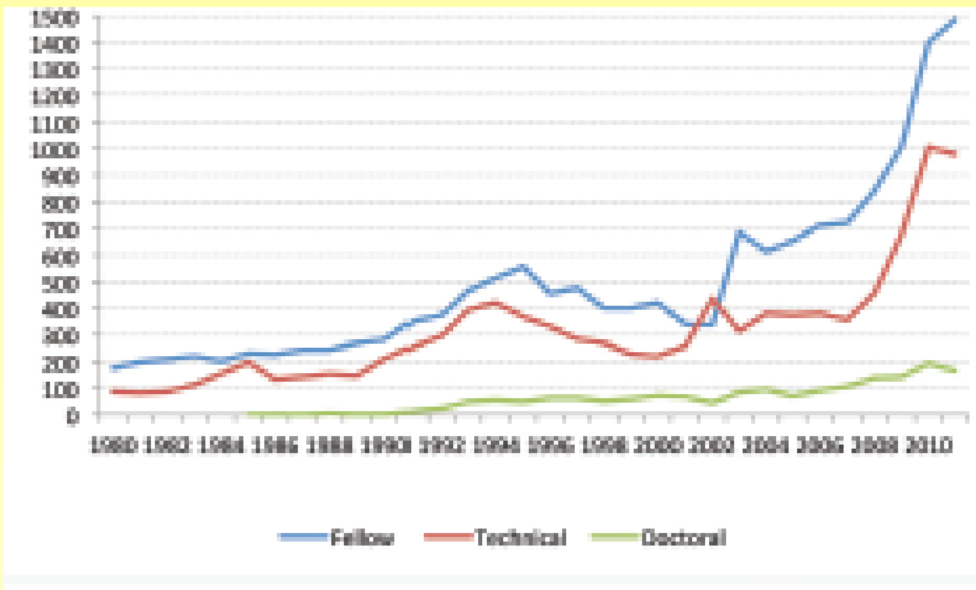
Radiography of a bat, recorded with a GEM detector

Knowledge Transfer through People

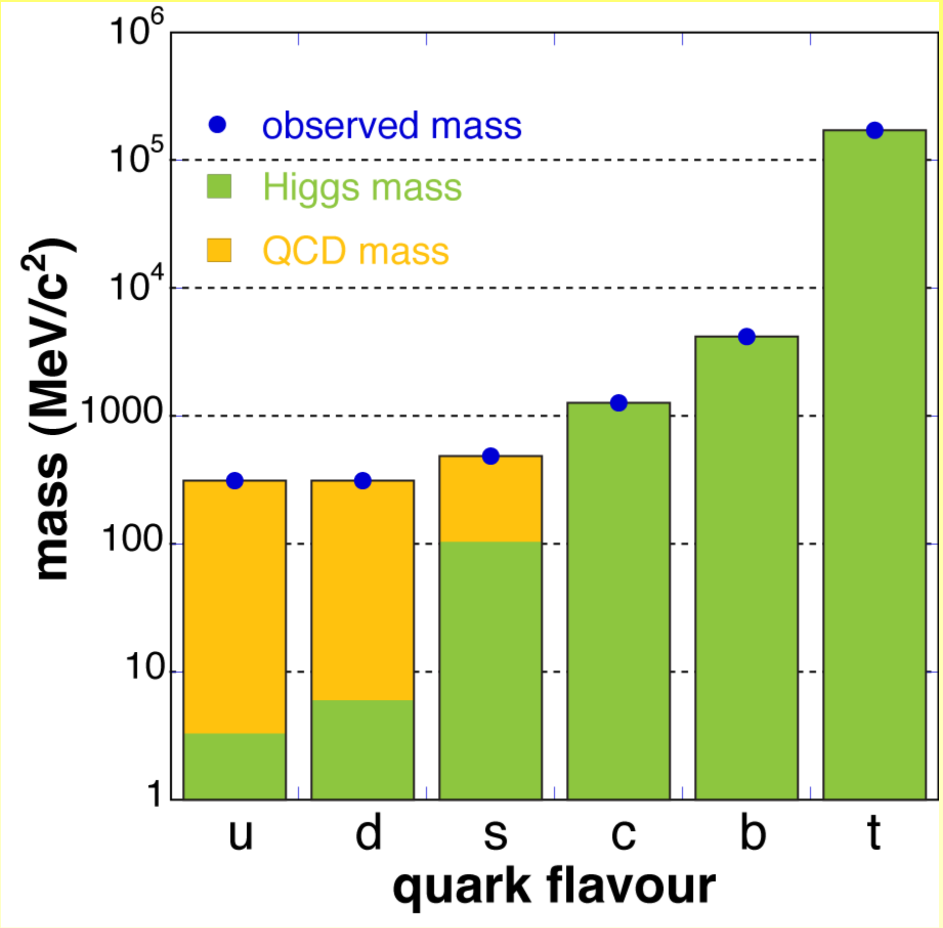
Every year hundreds of students come to CERN to contribute to our research programs

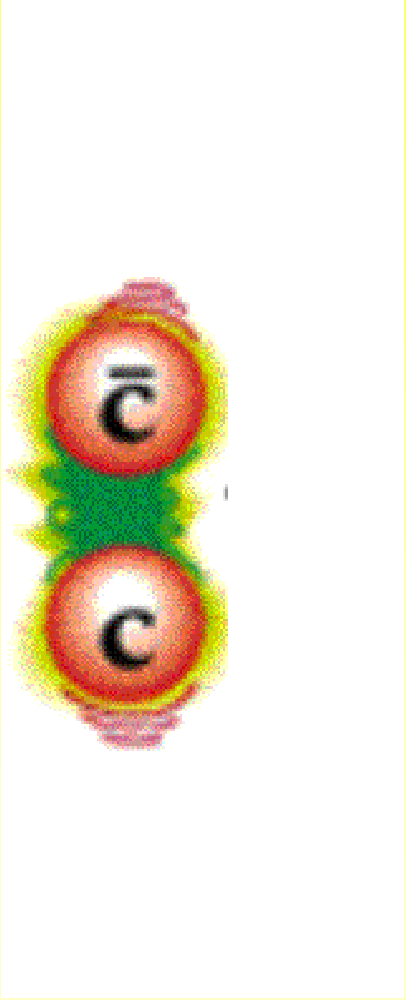
An opportunity for young people to learn in a multicultural environment

Not only for physicists! Also engineers, computer scientists, administrative students…

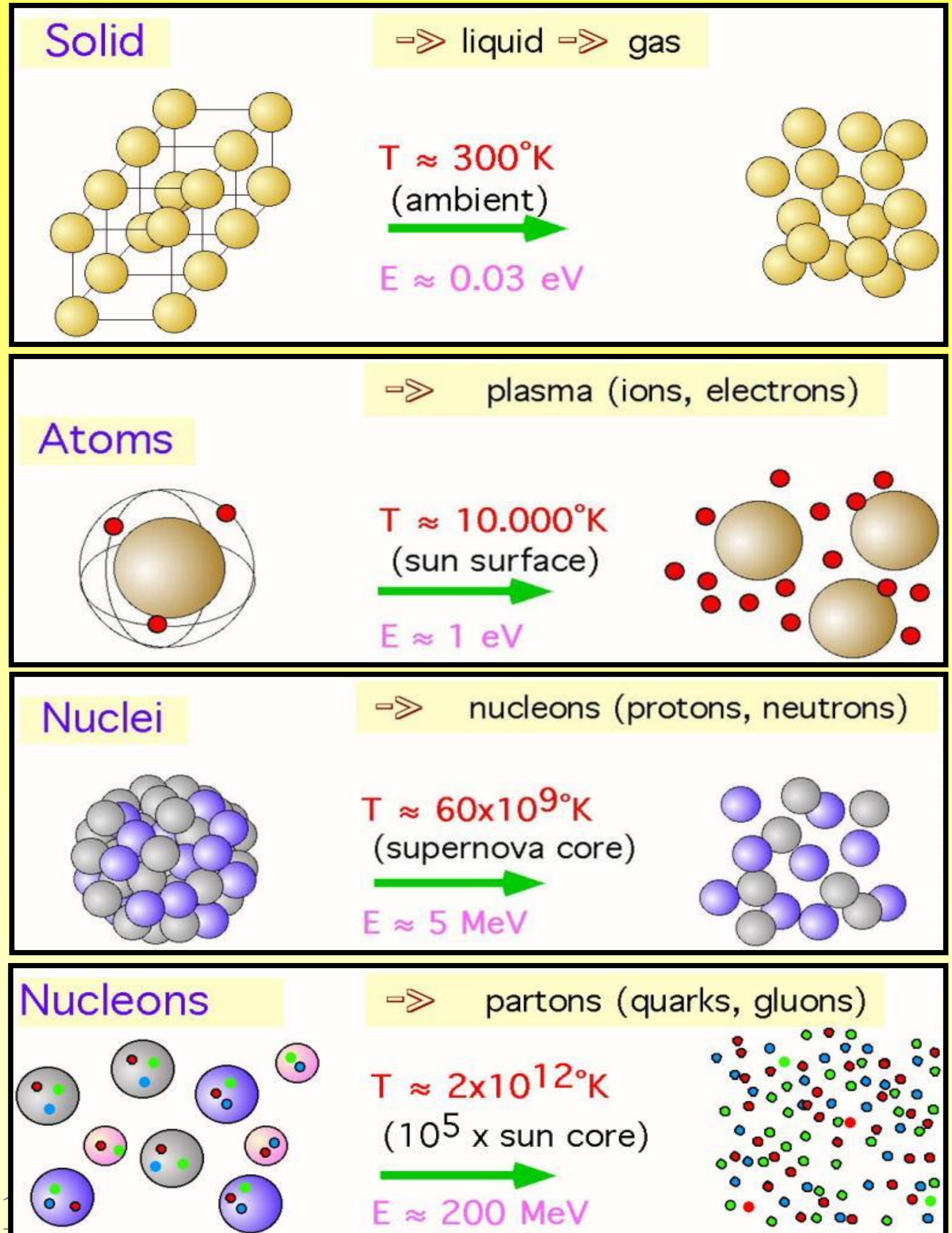


ALICE: study nuclear matter in extreme conditions of temperature and density, colliding nuclei at high energy





- Understand the origin of Hadron masses (the mass of matter around us!)
- Understand confinement of quarks into hadrons



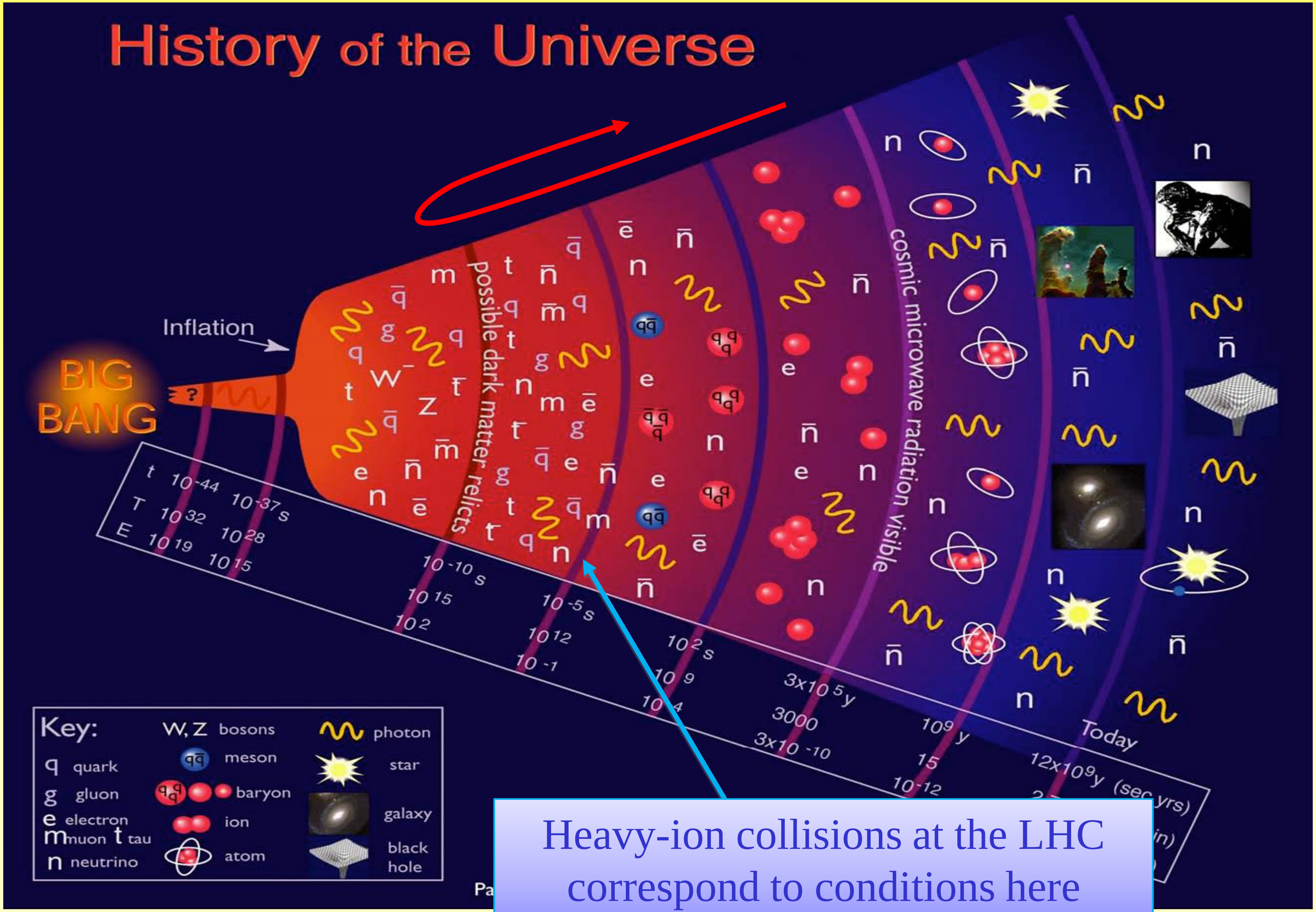
Melting Matter

If the force grows with distance, at small distances it is small (*asymptotic freedom*)

Idea: obtain deconfinement using collisions of Nuclei => compression and heating

Afterwards the system espands and cools, and ordinary hadrons reconstitute after a short time (about 10^{-23}s, or a few fm/c) … just as they did in the evolution of primordial Universe, some 11 millionth of a second after the Big Bang!

Create a droplet of matter

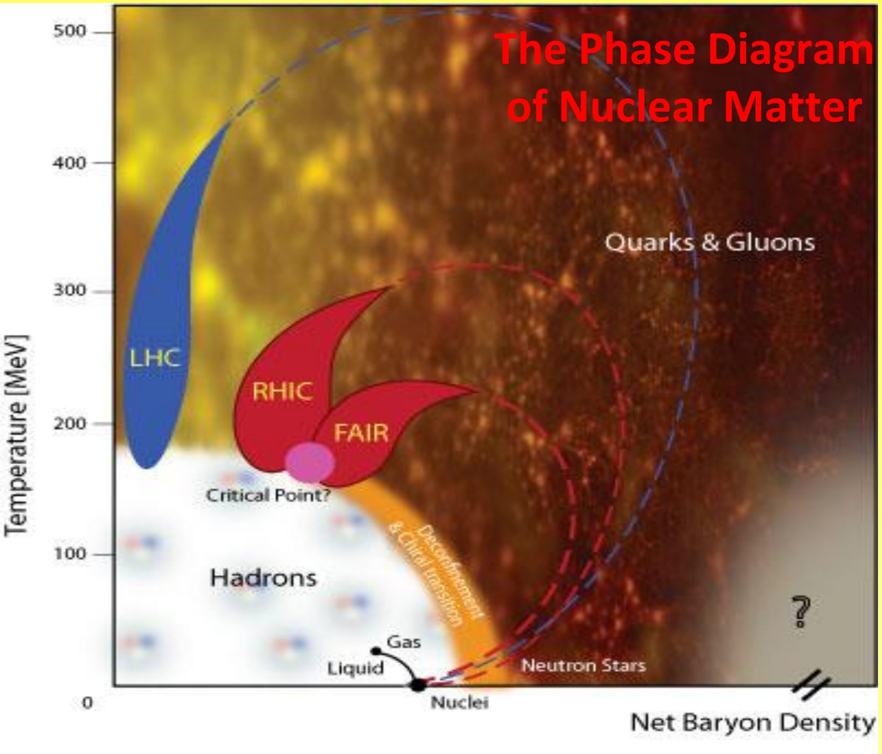


Heavy-ion collisions at the LHC correspond to conditions here

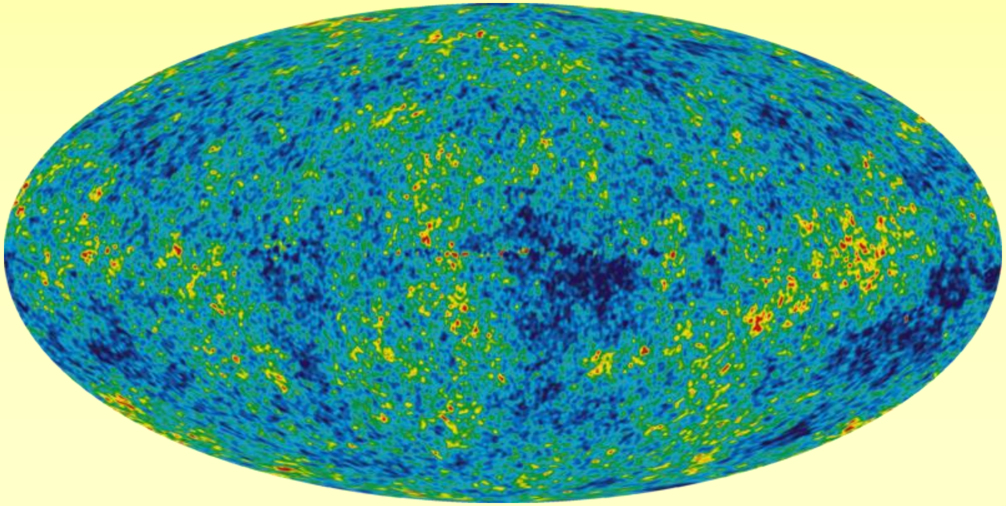
With conditions of the early Universe

What do we learn from Nuclear Collisions?

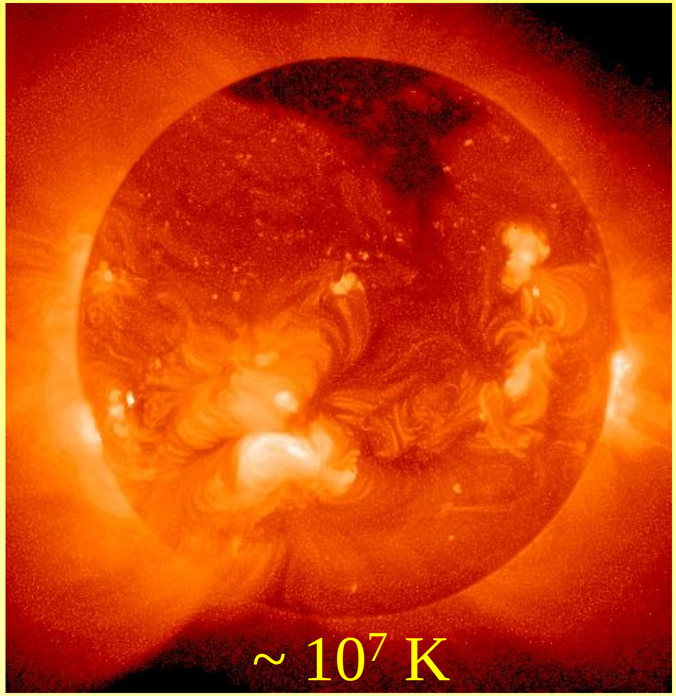
- how does matter behave in such extreme conditions?
- what were the properties of the Quark-Gluon Plasma?
  - Quantum Chromo-Dynamics (the theory of Strong Interaction) does not allow us to calculate them from first principles

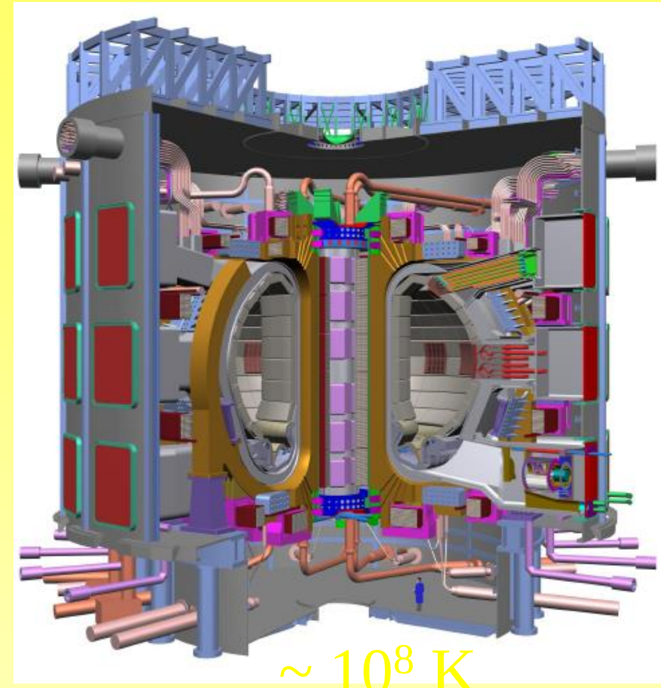


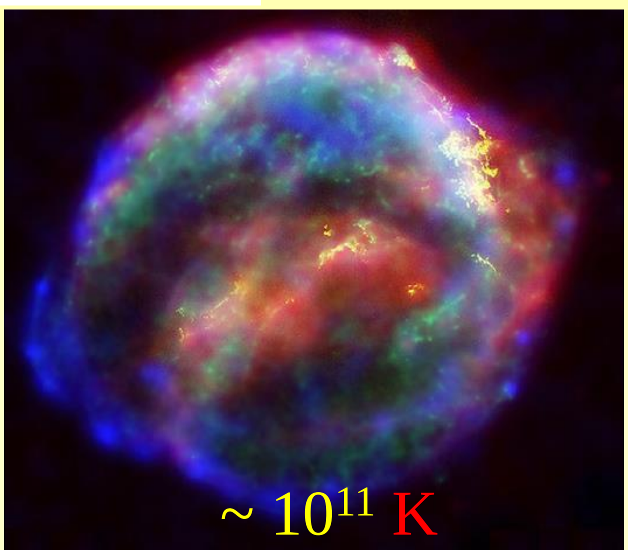
- Study the matter of the primordial Universe
  - even with the most powerful telescopes, it is only possible to look back in time ~ 400,000 y after the Big Bang…
- is it possible to reproduce such conditions in the laboratory?
  - about 2000 billion degrees?



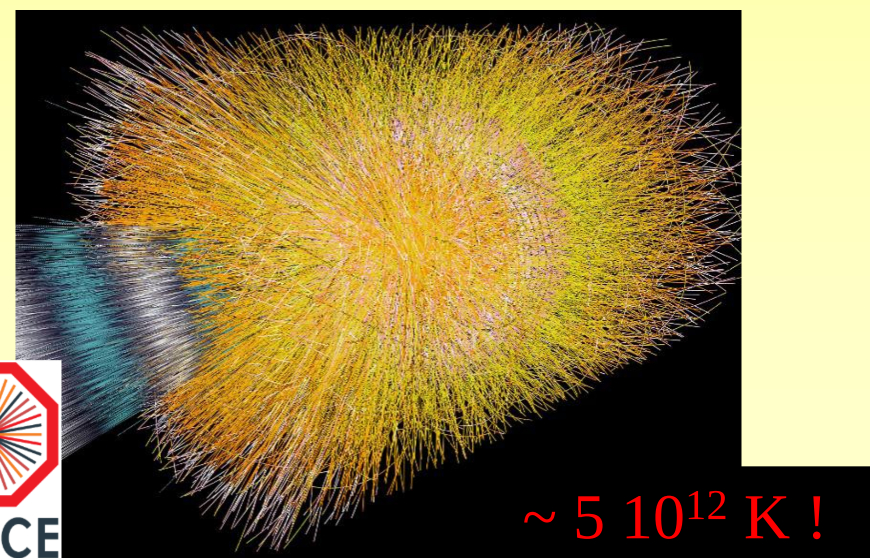
Temperature ~ 170 MeV (~ 10^{12} K) : How hot is it? 100,000 times the temperature at the center of the Sun!





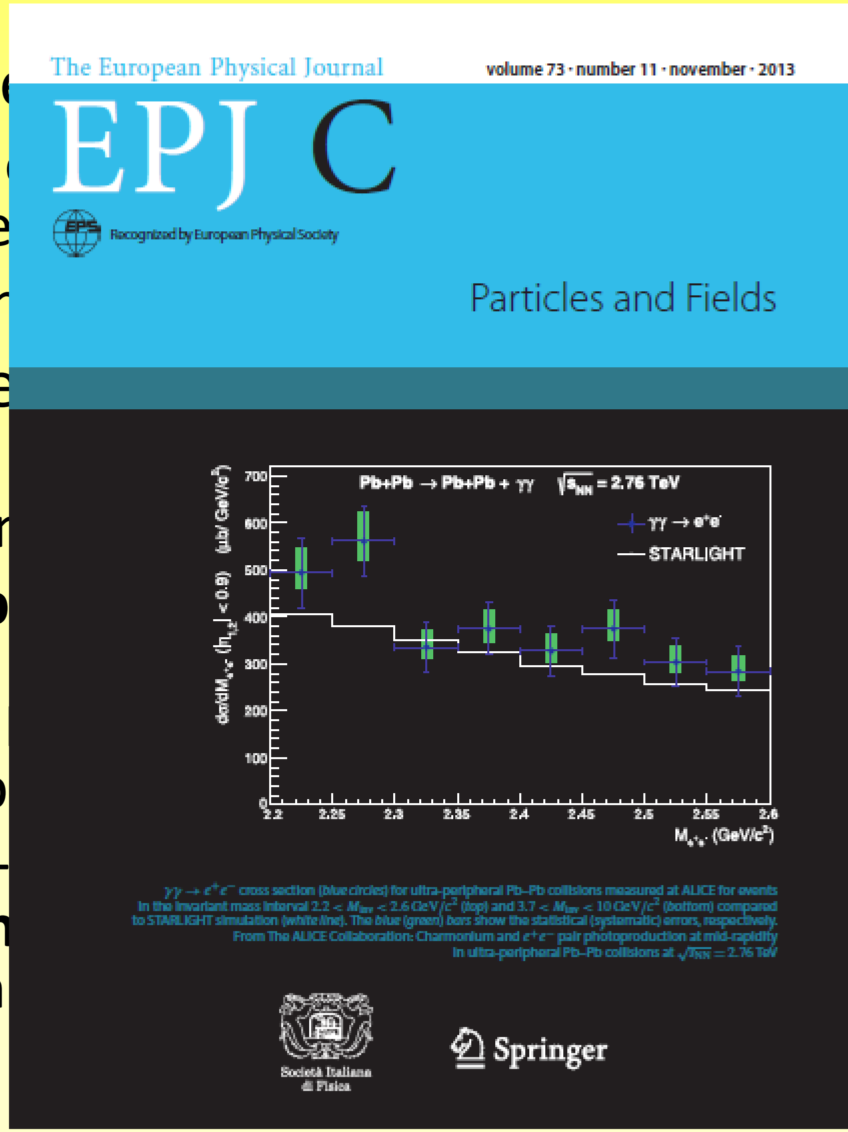


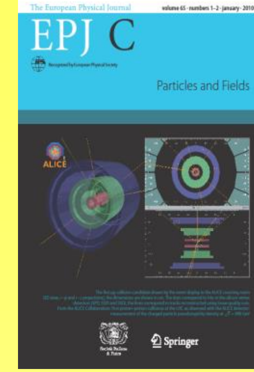
ALICE

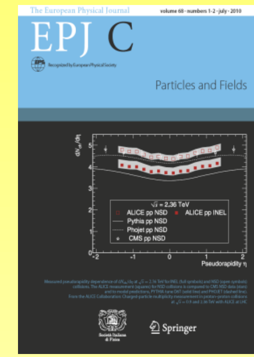


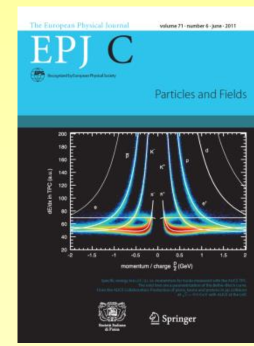
A program of major impact

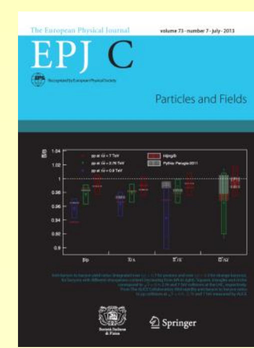
- A very larg… …olved
  - over a th… …the other LHC expe…
  - Very mar…
- A huge scie…
  - **77 ALICE** … …IC program in the sar…
  - **High imp**… …t the LHC after the … …E paper on flow in H… …cited physics p… …E and one from ATL…
  - **Several h**… …tional conferen…











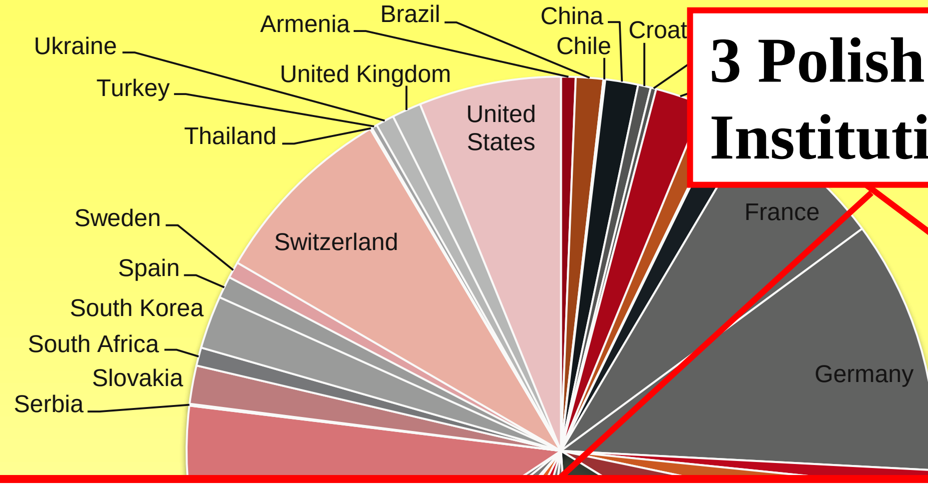
Articles from the LHC, ordered by number of citations (ISI) … with 5 more in the next 20 … so, 25% of the most relevant scientific production of the LHC!

Use the checkboxes to remove individual items from this Citation Report
or restrict to items published between 2009 and 2013 Go

		619	2522	5844	5295	0	14416	2883.20
1.	Title: **Observation of a new particle in the search for the Standard Model Higgs boson with the ATLAS detector at the LHC** Author(s): Aad, G.; Abajyan, T.; Abbott, B.; et al. Group Author(s): ATLAS Collaboration Source: PHYSICS LETTERS B Volume: **716** Issue: **1** Pages: **1-29** DOI: **10.1016/j.physletb.2012.08.020** Published: **SEP 17 2012**	0	0	132	749	0	881	440.50
2.	Title: **Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC** Author(s): Chatrchyan, S.; Khachatryan, V.; Sirunyan, A. M.; et al. Group Author(s): CMS Collaboration Source: PHYSICS LETTERS B Volume: **716** Issue: **1** Pages: **30-61** DOI: **10.1016/j.physletb.2012.08.021** Published: **SEP 17 2012**	0	0	119	717	0	836	418.00
3.	Title: **Combined results of searches for the standard model Higgs boson in pp collisions at root s=7 TeV** Author(s): Chatrchyan, S.; Khachatryan, V.; Sirunyan, A. M.; et al. Group Author(s): CMS Collaboration Source: PHYSICS LETTERS B Volume: **710** Issue: **1** Pages: **26-48** DOI: **10.1016/j.physletb.2012.02.064** Published: **MAR 29 2012**	0	0	221	76	0	297	148.50
4.	Title: **Combined search for the Standard Model Higgs boson using up to 4.9 fb(-1) of pp collision data at root s=7 TeV with the ATLAS detector at the LHC** Author(s): Aad, G.; Abbott, B.; Abdallah, J.; et al. Group Author(s): ATLAS Collaboration Source: PHYSICS LETTERS B Volume: **710** Issue: **1** Pages: **49-66** DOI: **10.1016/j.physletb.2012.02.044** Published: **MAR 29 2012**	0	0	223	61	0	284	142.00
5.	Title: **The ATLAS Simulation Infrastructure** Author(s): Aad, G.; Abbott, B.; Abdallah, J.; et al. Group Author(s): ATLAS Collaboration Source: EUROPEAN PHYSICAL JOURNAL C Volume: **70** Issue: **3** Pages: **823-874** DOI: **10.1140/epjc/s10052-010-1429-9** Published: **DEC 2010**	1	53	117	60	0	231	57.75
6.	Title: **Suppression of charged particle production at large transverse momentum in central Pb-Pb collisions at root s(NN)=2.76 TeV** Author(s): Aamodt, K.; Abrahantes Quintana, A.; Adamova, D.; et al. Group Author(s): ALICE Collaboration Source: PHYSICS LETTERS B Volume: **696** Issue: **1-2** Pages: **30-39** DOI: **10.1016/j.physletb.2010.12.020** Published: **JAN 24 2011**	0	63	80	54	0	197	65.67
7.	Title: **Elliptic Flow of Charged Particles in Pb-Pb Collisions at root s(NN)=2.76 TeV** Author(s): Aamodt, K.; Abelev, B.; Abrahantes Quintana, A.; et al. Group Author(s): ALICE Collaboration Source: PHYSICAL REVIEW LETTERS Volume: **105** Issue: **25** Article Number: **252302** DOI: **10.1103/PhysRevLett.105.252302** Published: **DEC 13 2010**	0	47	82	64	0	193	48.25
8.	Title: **Higher Harmonic Anisotropic Flow Measurements of Charged Particles in Pb-Pb Collisions at root s(NN)=2.76 TeV** Author(s): Aamodt, K.; Abelev, B.; Abrahantes Quintana, A.; et al. Group Author(s): ALICE Collaboration Source: PHYSICAL REVIEW LETTERS Volume: **107** Issue: **3** Article Number: **032301** DOI: **10.1103/PhysRevLett.107.032301** Published: **JUL 11 2011**	0	11	78	68	0	157	52.33
9.	Title: **Observation of a Centrality-Dependent Dijet Asymmetry in Lead-Lead Collisions at root s(NN)=2.76 TeV with the ATLAS Detector at the LHC** Author(s): Aad, G.; Abbott, B.; Abdallah, J.; et al. Group Author(s): ATLAS Collaboration Source: PHYSICAL REVIEW LETTERS Volume: **105** Issue: **25** Article Number: **252303** DOI: **10.1103/PhysRevLett.105.252303** Published: **DEC 13 2010**	0	39	70	41	0	150	37.50
10.	Title: **Transverse-Momentum and Pseudorapidity Distributions of Charged Hadrons in pp Collisions at root s=7 TeV** Author(s): Khachatryan, V.; Sirunyan, A. M.; Tumasyan, A.; et al. Group Author(s): CMS Collaboration Source: PHYSICAL REVIEW LETTERS Volume: **105** Issue: **2** Article Number: **022002** DOI: **10.1103/PhysRevLett.105.022002** Published: **JUL 6 2010**	9	54	43	27	0	133	33.25

ALICE: A Large International Collaboration

~ 1500 **Members**
from both NP and HEP communities
37 Countries
149 Institutes
~ 160 MCHF capital cost
(+ 'free' magnet)



3 Polish Institutions

His

1990
1992
2000
2002
2008
2009
4 TP
1996
1999
2006
2012
the years 2016-2020 approved!

34 Collaborators coming from 3 Institutes:

- National Centre for Nuclear Studies, Warsaw
- The Henryk Niewodniczanski Institute of Nuclear Physics, Cracow
- Warsaw University of Technology, Warsaw

POLAND REPRESENTATIVES

Jerzy BARTKE

- Member of the Collaboration Board

Marek KOWALSKI

- Member of the Financial Board
- Member of the Collaboration Board
- Member of the Computing Board
- Henryk Niewodniczanski Institute Team Leader

Jan PLUTA

- Member of the Collaboration Board
- Warsaw University of Technology Team Leader

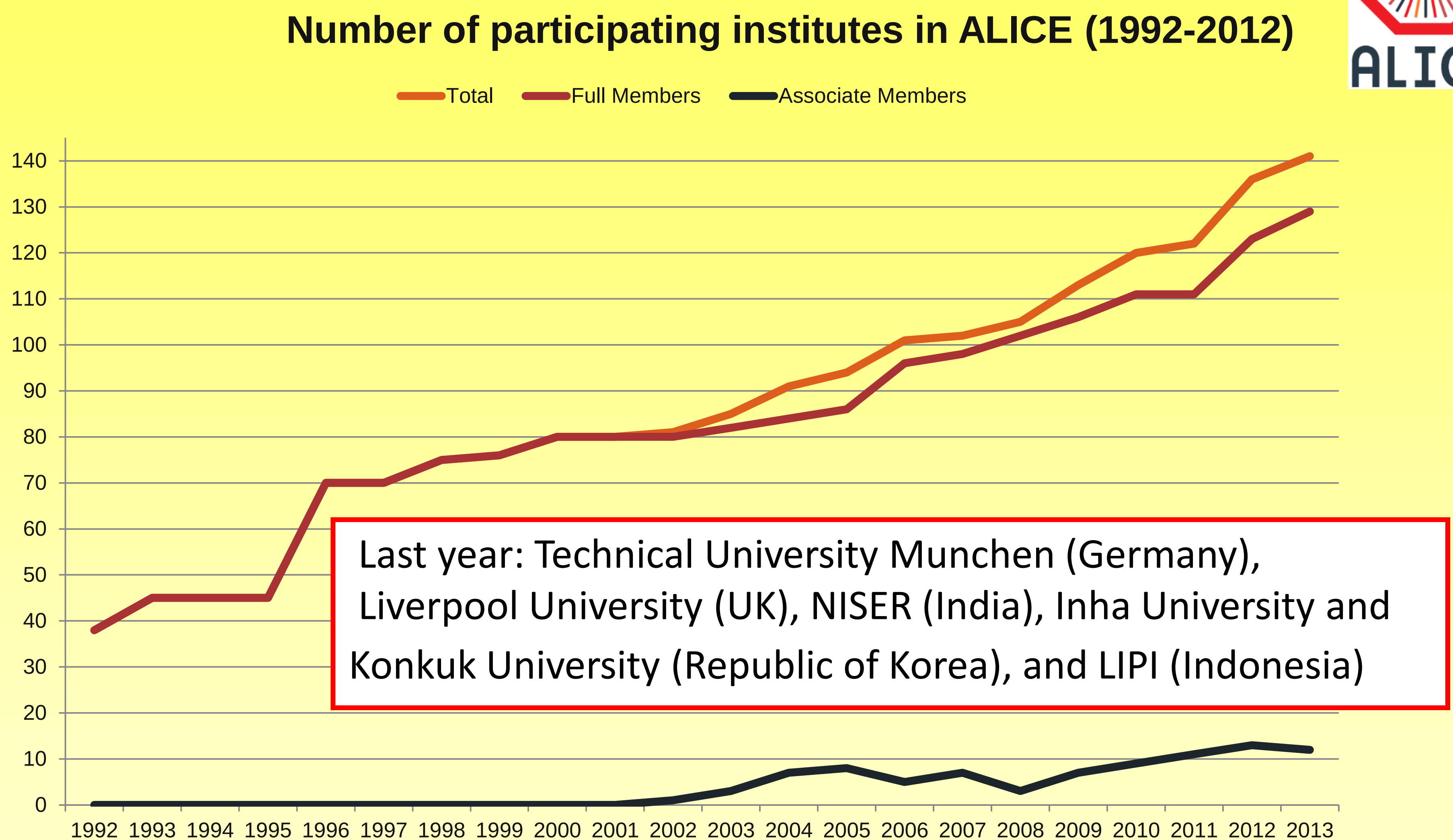
Adam KISIEL

- Member of the Collaboration Board
- Warsaw University of Technology Deputy Team Leader
- Convenor of the Femtoscopy PAG

Teodor SIEMIARCZUK

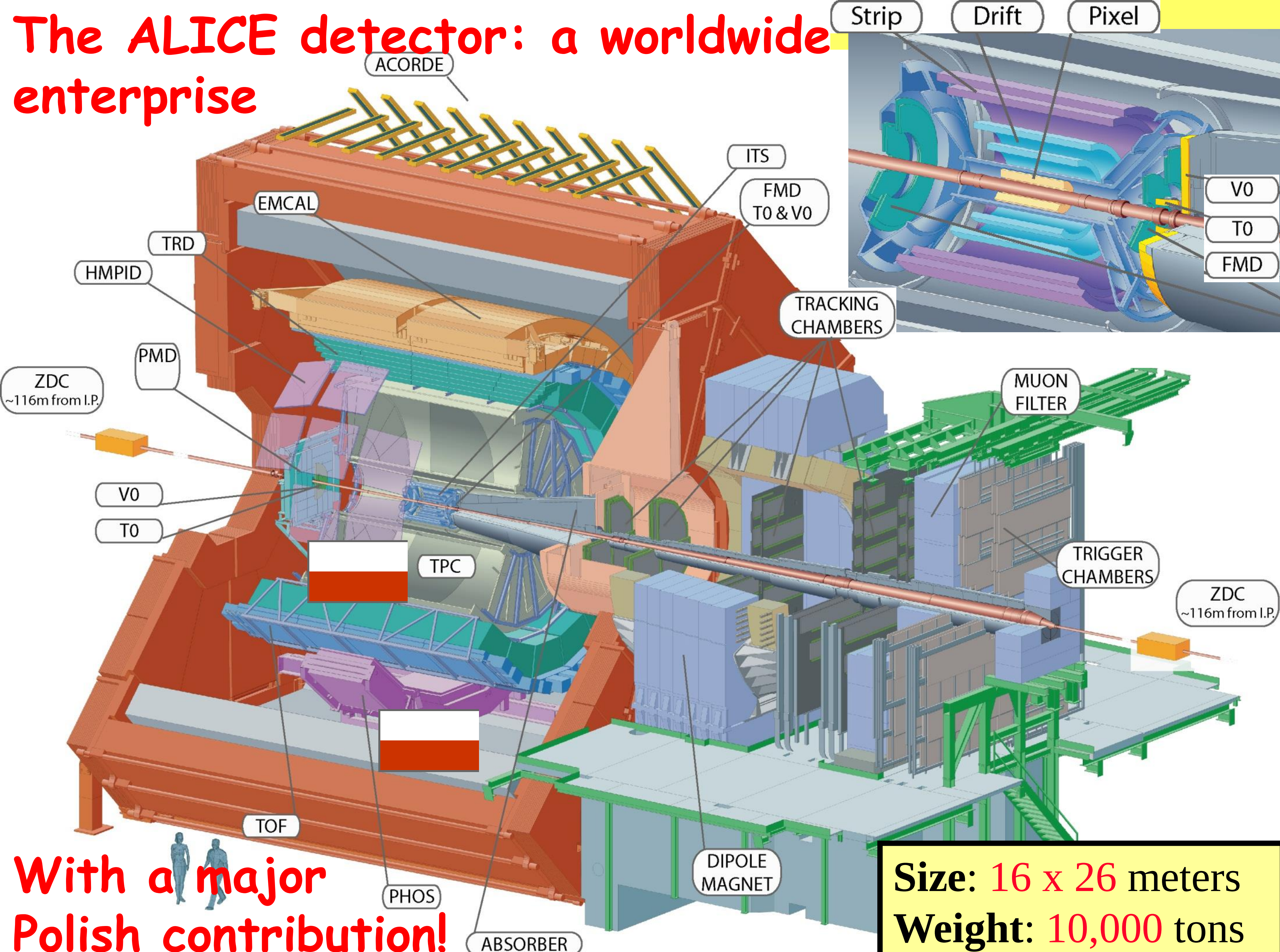
- Member of the Collaboration Board
- National Centre for Nuclear Studies Team Leader

ALICE Continues to grow!



A scientific and technological program with great prospects!

The ALICE detector: a worldwide enterprise



With a major Polish contribution!

Size: 16 x 26 meters
Weight: 10,000 tons

And with a great future!

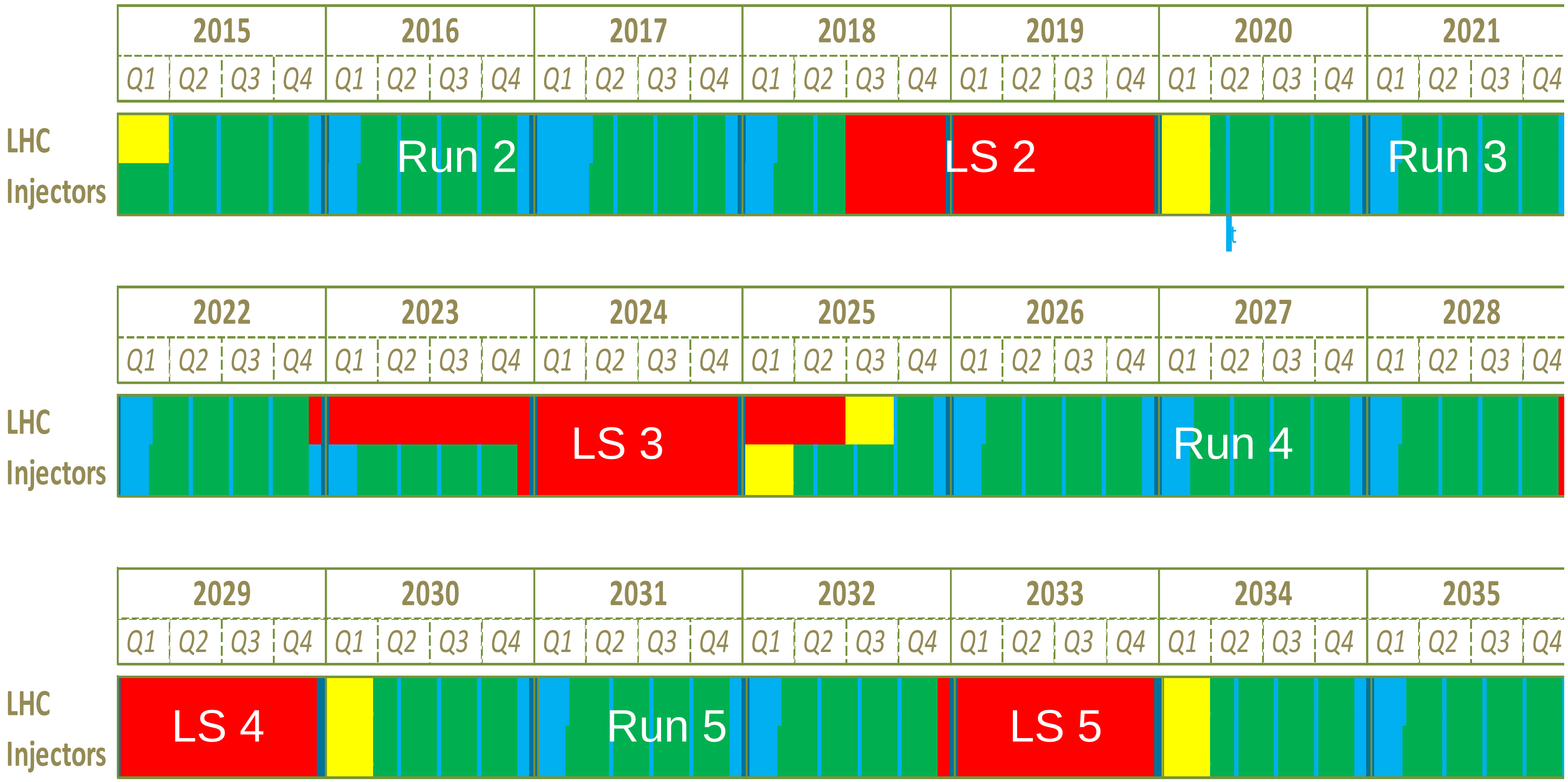
- **So far (RUN1):**

year	system	energy $\sqrt{s_{NN}}$ TeV	integrated luminosity
2010	Pb – Pb	2.76	~ 10 μb^{-1}
2011	Pb – Pb	2.76	~ 0.1 nb^{-1}
2013	p – Pb	5.02	~ 30 nb^{-1}

- **THE FUTURE :**
  - **RUN2 (2015, 2016, 2017) : will allow to approach the 1 nb^{-1} for PbPb collisions, with improved detectors and double energy**
  - **RUN3 + RUN4 (19, 20, 21 and 24, 25, 26): 10 nb^{-1} with major detector improvements**
- **So: three phases, each jumping one order of magnitude in statistics and progressively improving the detectors**

LHC schedule beyond LS1

Only EYETS (19 weeks) (no Linac4 connection during Run2)
LS2 starting in 2018 (July) 18 months + 3months BC (Beam Commissioning)
LS3 LHC: starting in 2023 => 30 months + 3 BC
injectors: in 2024 => 13 months + 3 BC



1-month runs with Heavy Ions every year, in the fall

Summary of ALICE upgrades

ALICE

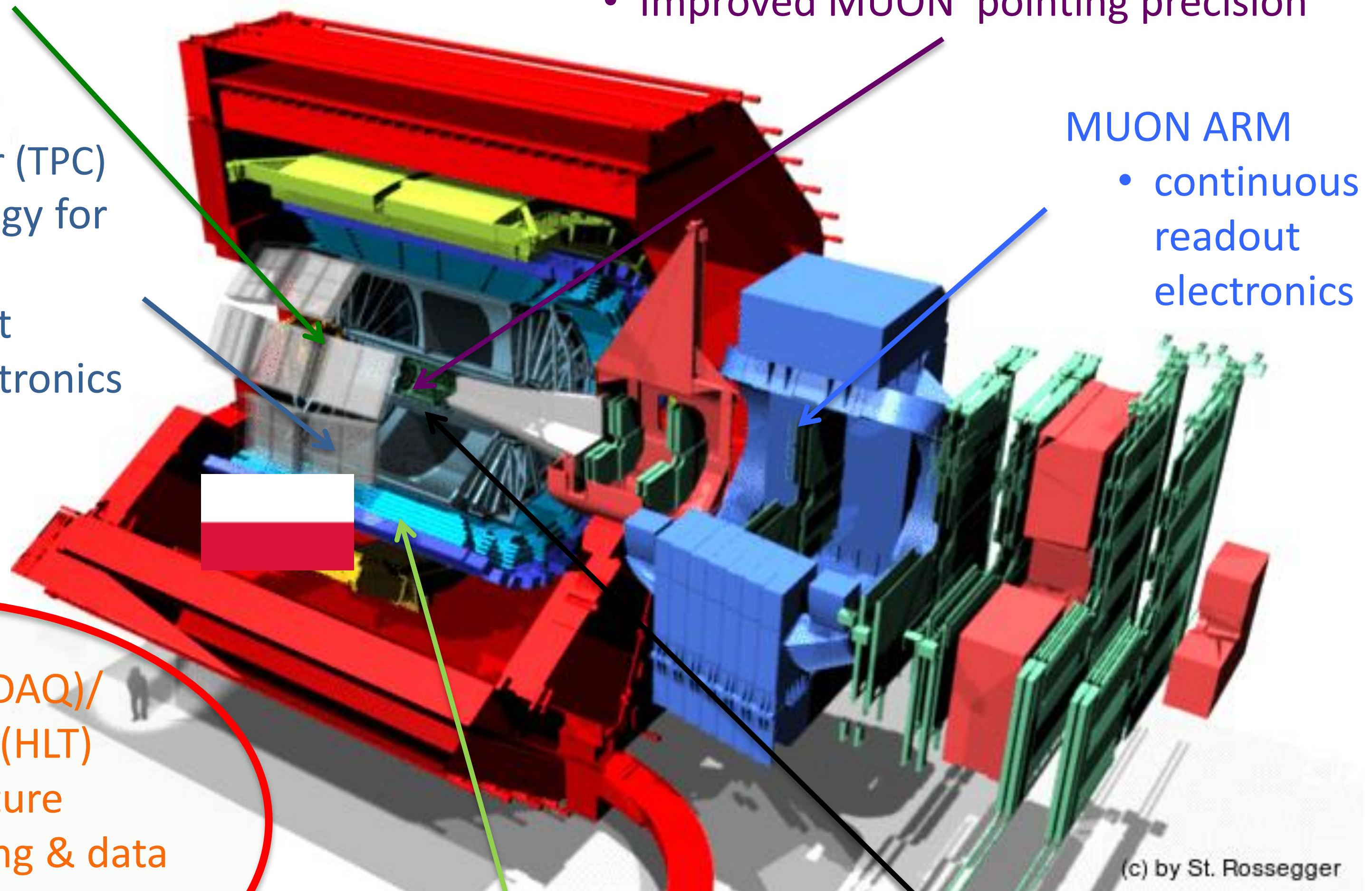
New Inner Tracking System (ITS)
- improved pointing precision
- less material -> thinnest tracker at the LHC

Muon Forward Tracker (MFT)
- new Si tracker
- Improved MUON pointing precision

Time Projection Chamber (TPC)
- new GEM technology for readout chambers
- continuous readout
- faster readout electronics

MUON ARM
- continuous readout electronics

New Central Trigger Processor



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

TOF, TRD
- Faster readout

New Trigger Detectors (FIT)

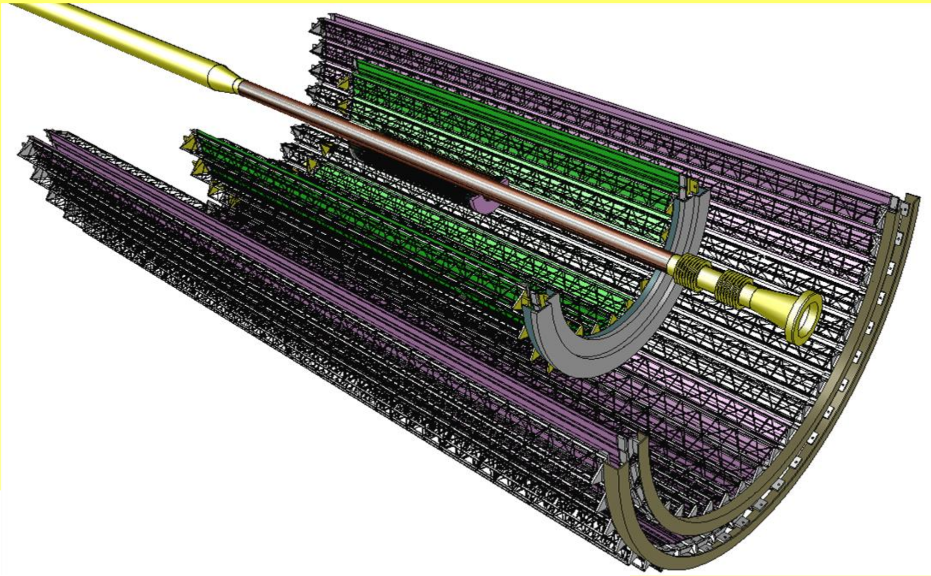
Pushing technology limits...

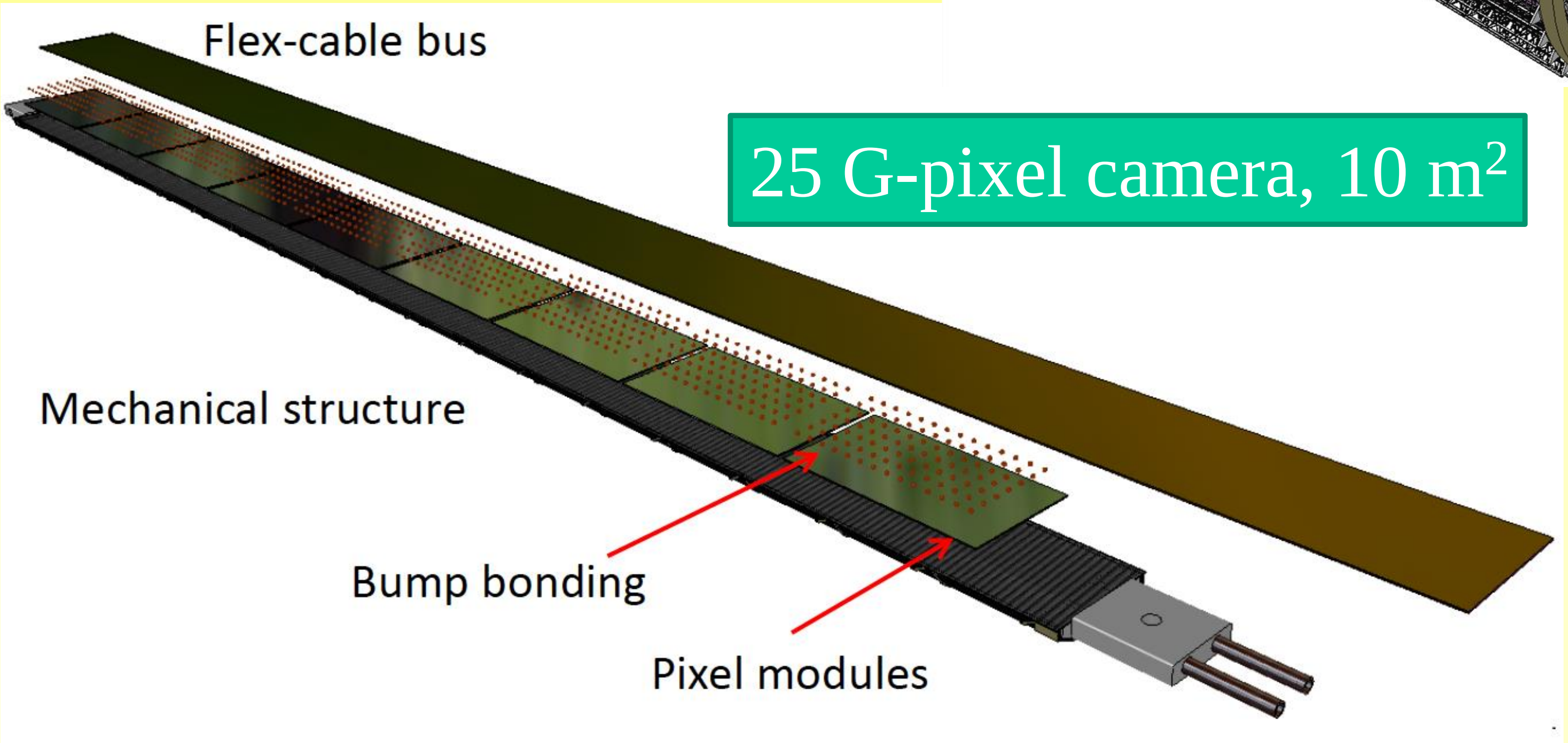
- The LHC experiments are amongst **most complex & challenging instruments** ever built
  - required years of R&D
- Technologies
  - **mechanics & engineering**
    - micrometer precision, advanced materials, hostile environment (radiation, chemical)
  - **sensor technology**
    - ‘detectors’ for the invisible: from μm thick silicon wafers to tons of Tungsten
  - **micro-electronics**
    - custom designed VLSI circuits, electronic boards, data links, ...
  - **Information Technology**
    - large scale & distributed computing (the **GRID**)

Being developed now

Inner Barrel: 3 layers
Outer Barrel: 4layers

Detector module (Stave) consists of
- Carbon fibber mechanical support
- Cooling unit
- Polyimide printed circuit board
- Silicon chips (CMOS sensors)





Custom electronics….

Several technologies are being considered

Hybrid pixel detectors

- Edgeless sensors (100µm) + front-end chip (50µm) in 130 nm CMOS

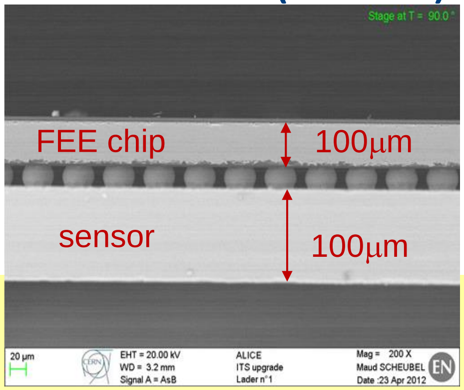
Monolithic pixel detectors

- MIMOSA like in 180 nm CMOS
- INMAPS in 180 nm CMOS

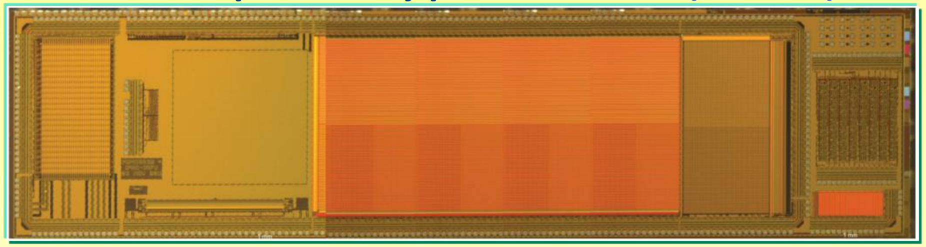
} Tower/Jazz

- LePix in 90nm CMOS → IBM

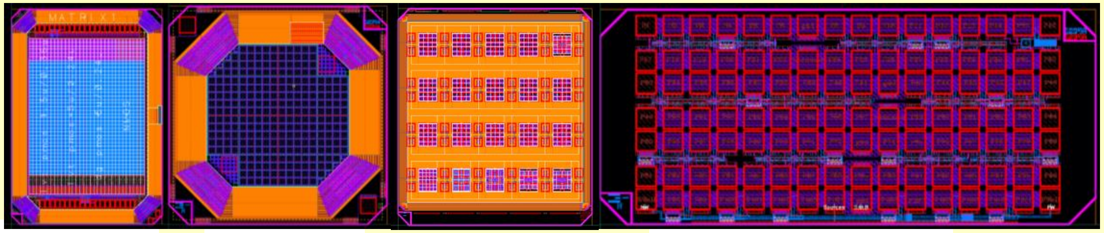
HYBRID (CERN)



MISTRAL prototype circuit (IPHC)

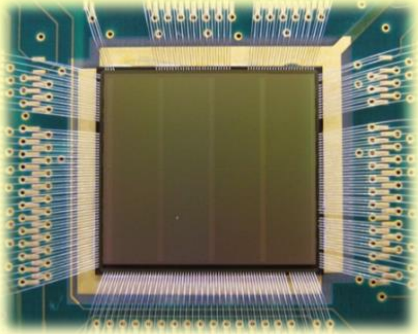


LePIX prototype circuit (CERN)



Matrix1 | Diode | Breakdown test | Transistor test

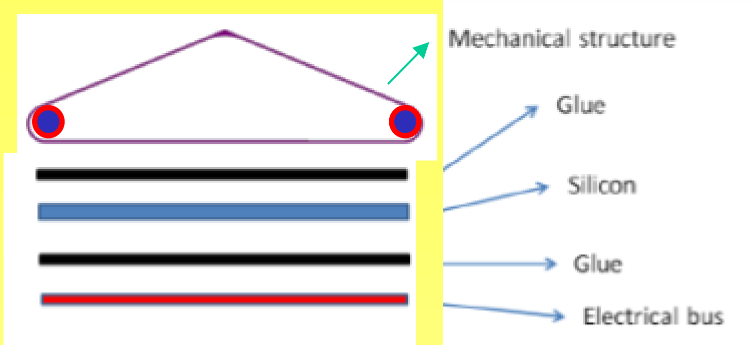
INMAPS (RAL)

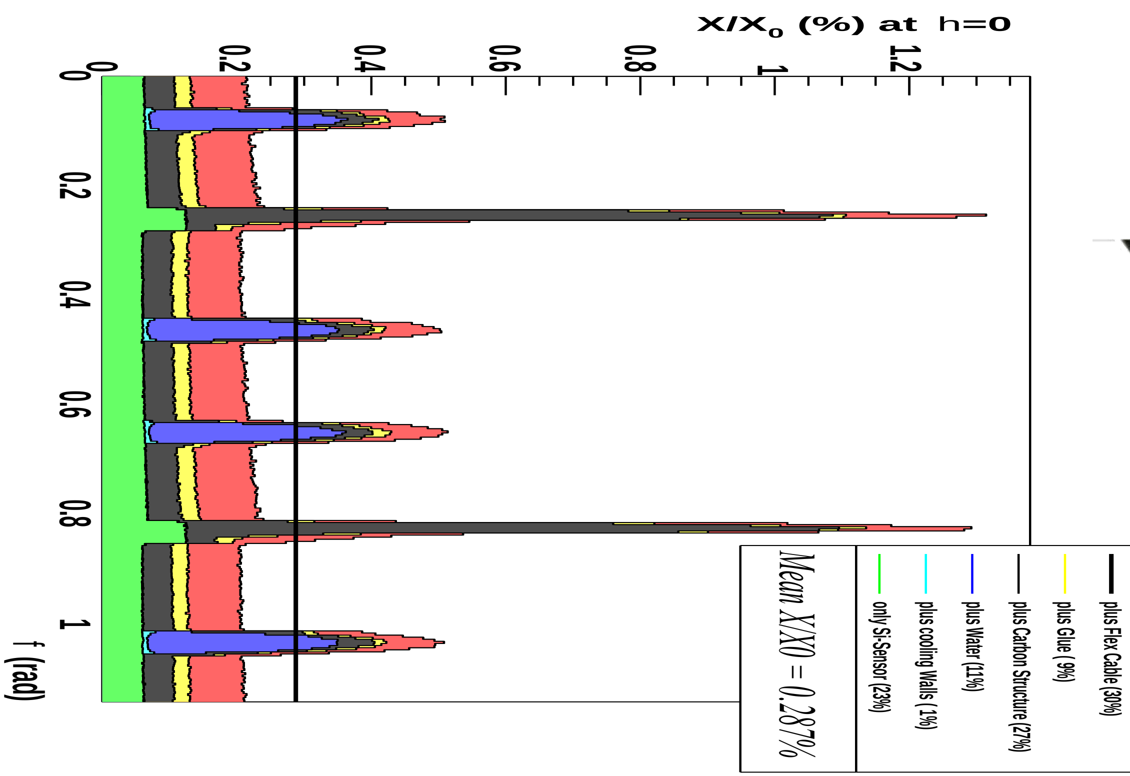


TPAC prototype
50 µm pixel - over 150 CMOS transistors

R&D on mechanical structure

Ladder prototype equipped with dummy components

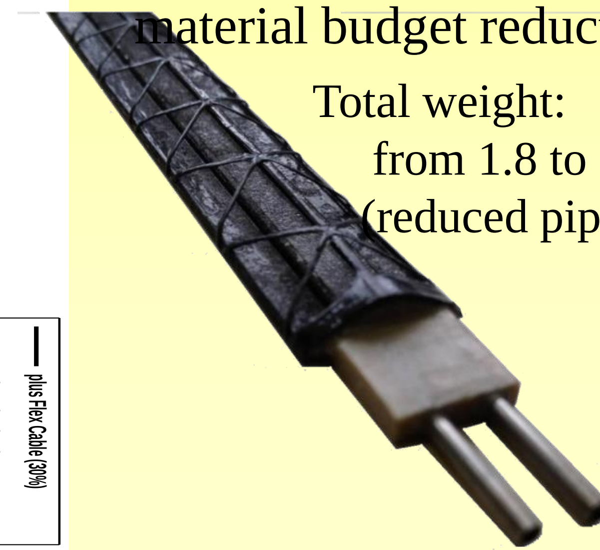




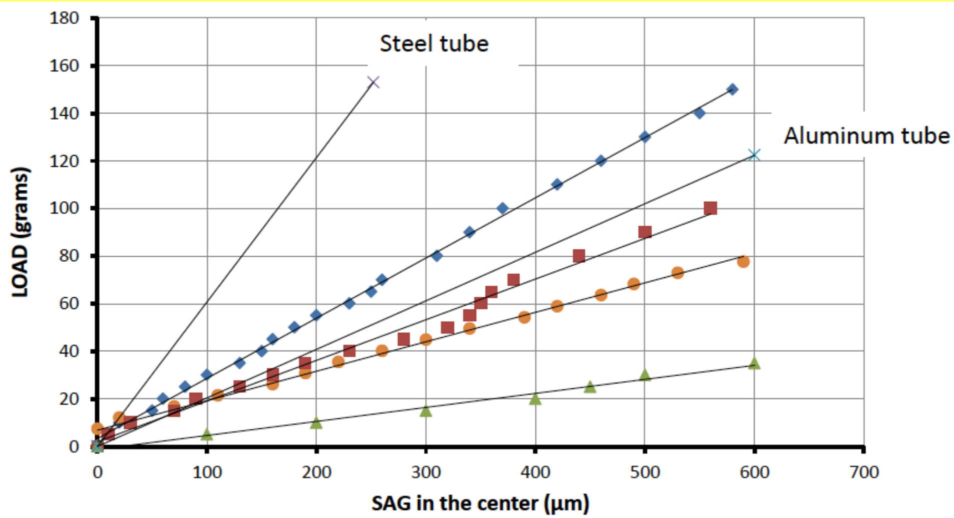
MECHANICS &COOLING

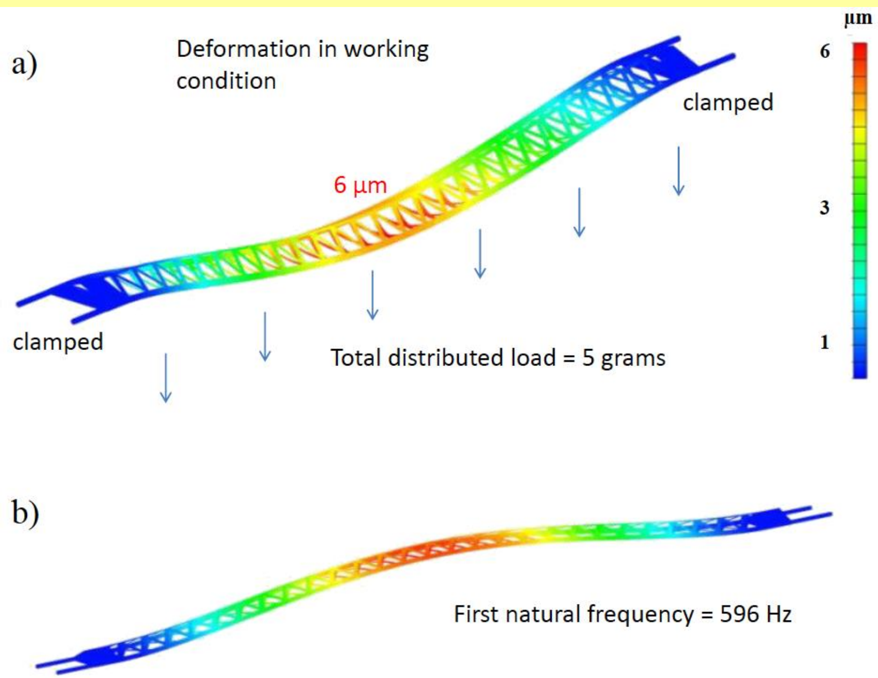
- ✓ Design optimization for material budget reduction

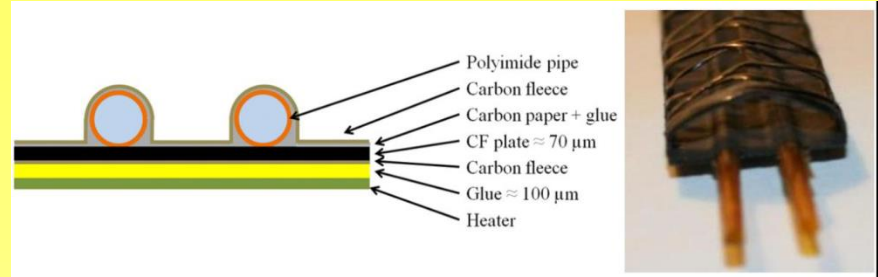
Total weight:
from 1.8 to 1.4 grams
(reduced pipe diameter)

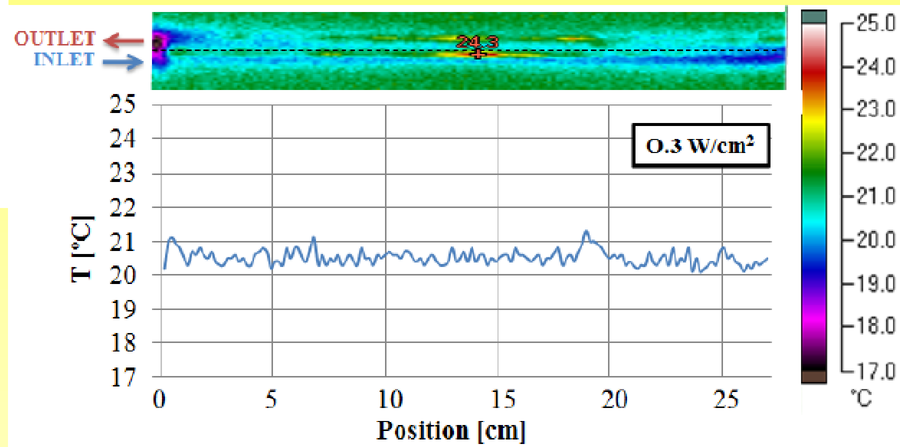


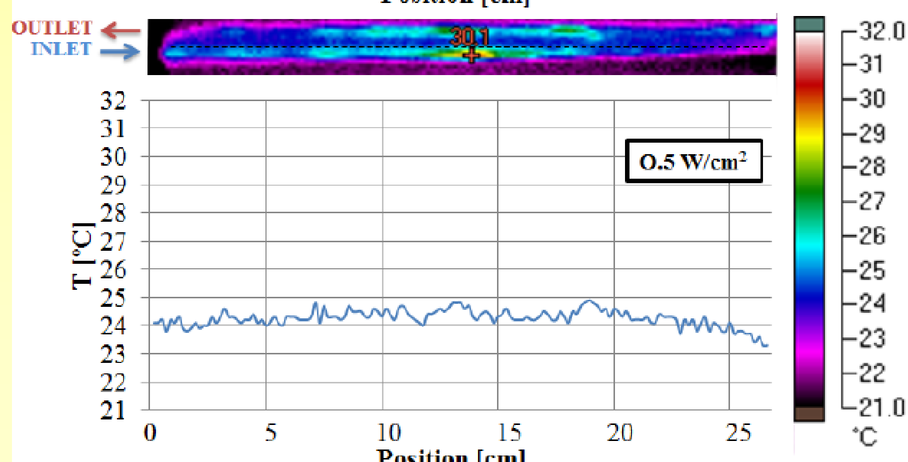
Structural & thermal tests…



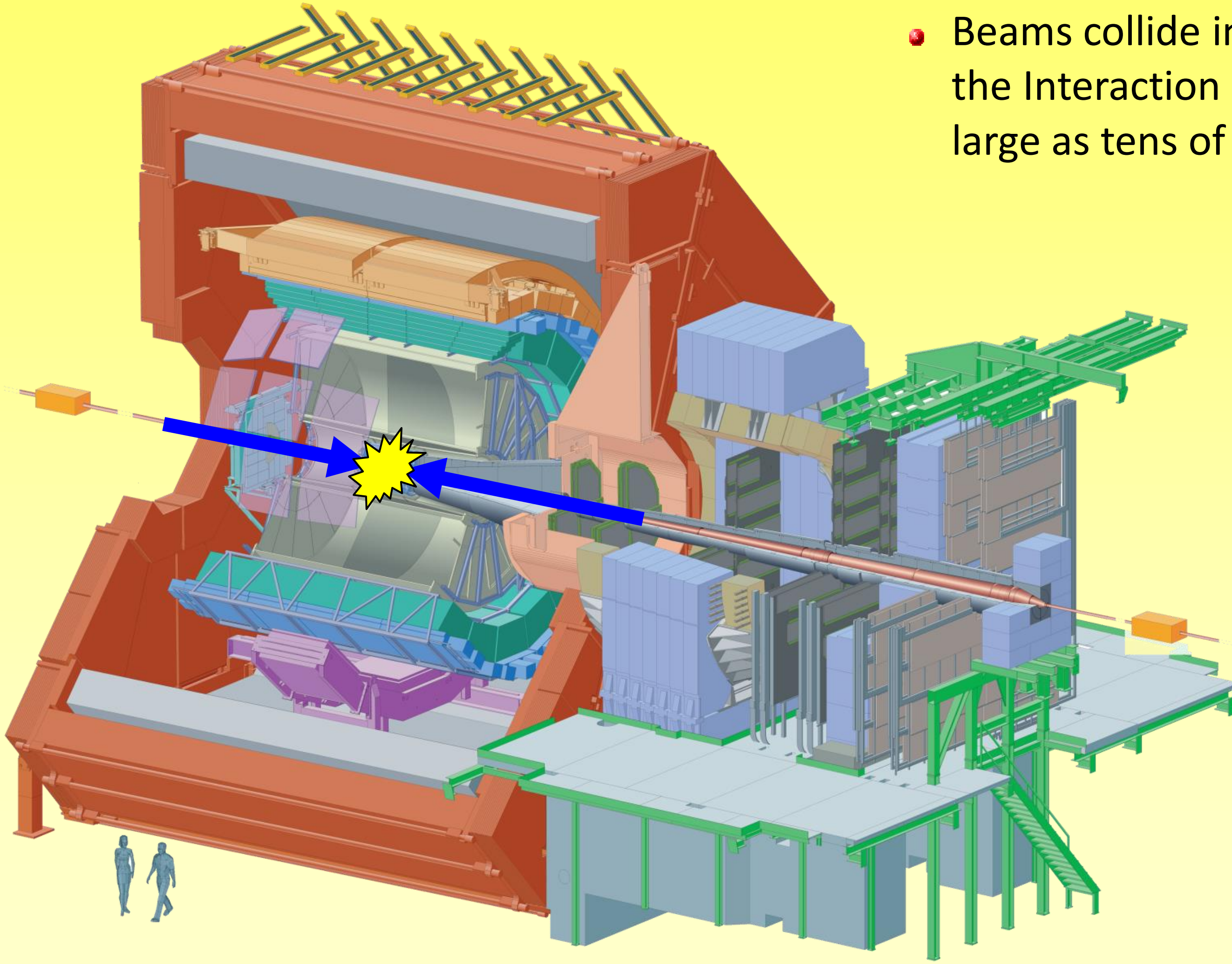






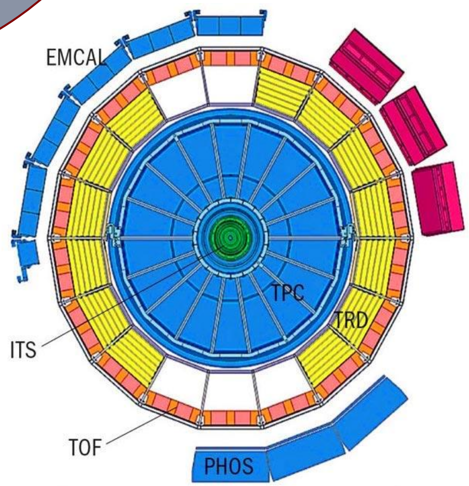


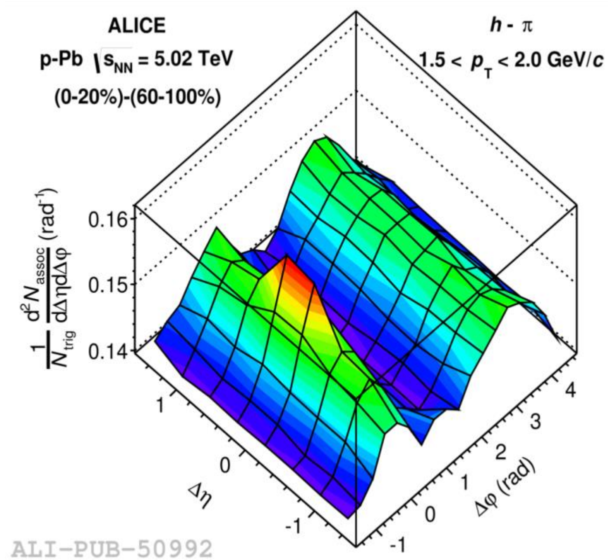
From collisions to data



- Beams collide inside the detector in the Interaction Point, at rates as large as tens of kHz
- Particles produced in the collisions traverse the detectors and leave signals:
  - Manage data input
  - Compress information
  - Store final information

The ALICE Online-Offline (O2) Project





From Detector Readout to Analysis: What is the “optimal” computing architecture?

ALICE O^2 Upgrade Plans: Looking to 2018 →

Now: reducing the event rate from 40 MHz to ~ 1 kHz

- ***Select the most interesting particle interactions***
- Reduce the data volume to a manageable size

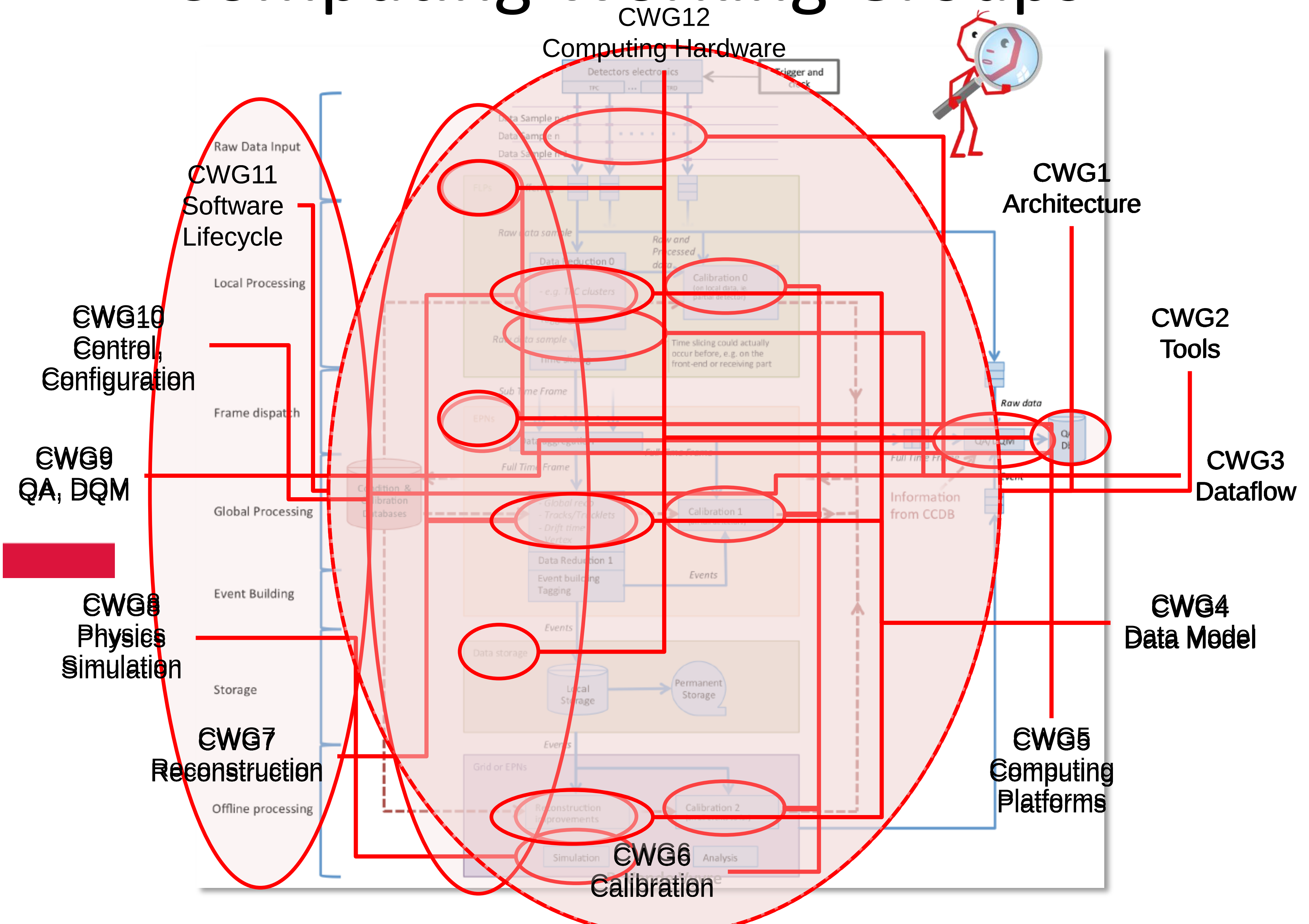
PARADIGM SHIFT

After 2018:

- Much more data (×100) because:
  - Higher interaction rate
  - More violent collisions → More particles → More data (1 TB/s)
  - Physics topics require measurements characterized by very small signal/background ratio → large statistics
  - Large background → traditional triggering or filtering techniques very inefficient for most physics channels
  - ***Read out all particle interactions (PbPb) at the anticipated interaction rate of 50 kHz***
- No more data selection
  - Continuous detector read-out → Data less structured than in the past
  - Read-out and process all interactions with a standard computer farm. ~ 1'500 nodes with the computing power expected by then

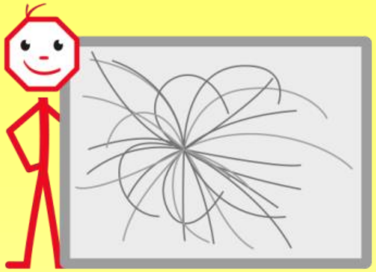
- **Total data throughput out of the detectors: 1 TB/s**

Computing Working Groups



O^2 Computing Working Group 9

- Supervises and coordinates the effort on
  - the Data Quality Monitoring (DQM)
  - the Quality Assurance (QA)
  - the Visualization, incl. the Event Display
- For Run 2 (2015) and Run 3 (2019)
- Main tasks currently
  - Event Display redesign for Run 2
  - DQM/QA preparation for Run 2
  - Requirements and specifications document for Run 3
  - Technical Design Report + feasibility tests for Run 3
- **WUT is a key player in CWG9**
  - 4 out of 11 members are from WUT
  - Soon responsible of the Visualization in ALICE
  - Participation in the design and development of DQM and QA



WARSAW UNIVERSITY OF TECHNOLOGY CONTRIBUTION TO ALICE

"Faculty of Physics, Heavy Ion Reaction Group, HIRG"

Team Leader: Jan Pluta
Deputy: Adam Kisiel

✓In ALICE since 1998
✓During the construction phase:

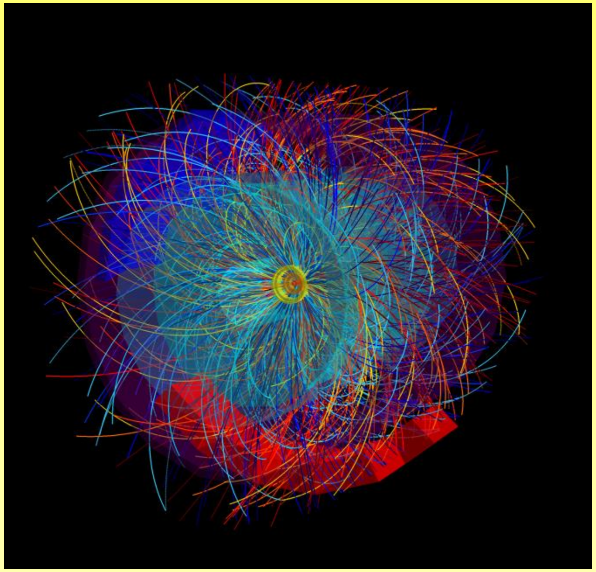
- design and implementation of Detector Construction Data-Base (DCDB),
- estimation of detector performance for the analysis of momentum correlations.

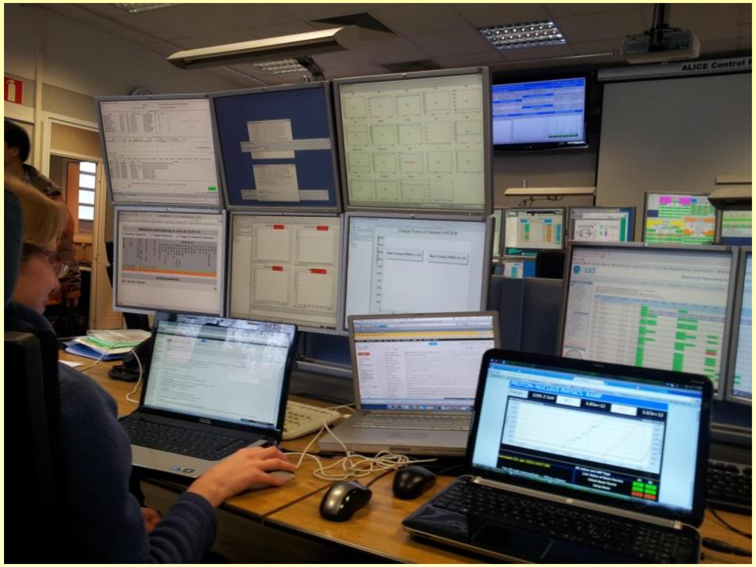
✓During the operation phase:

- analysis of momentum (femtoscopy) and angular correlations,
- visualization of ALICE detector and events (new group),
- maintenance of DCDB.

WARSAW UNIVERSITY OF TECHNOLOGY IN THE ALICE UPGRADE

- Participation in the O^2 Project (upgrade of Online & Offline systems)
- WUT has joined the Computing Working Group 9 – Quality Assurance, Data Quality Monitoring and Visualization
- WUT will contribute to the data visualization system in ALICE





WARSAW UNIVERSITY OF TECHNOLOGY
WUT STUDENTS IN ALICE AT CERN

- **3-5 undergraduate + 3 Ph.D. students from WUT come to CERN each year to work in ALICE:**
  - Data analysis – femtoscopy & angular correlations
  - Outreach – International MasterClasses
  - Shifts – taking responsibility for one of the running systems as crew member in the ALICE Control Room during data taking
- Internships have been funded 50/50 by ALICE and WUT
- Supervisors from CERN:
  - Dr. Panagiota Foka
  - Dr. Andreas Morsch
  - Dr. Despina Hatzifotiadou
  - Prof. Adam Kisiel (Research Fellow at CERN 2007-2011, now Faculty of Physics, WUT)
- Malgorzata Janik and Lukasz Graczykowski (Ph.D. students at WUT) have spent at CERN in total 14 months since 2009

WARSAW UNIVERSITY OF TECHNOLOGY

FUTURE & OTHER INVOLVEMENT POSSIBILITES

Future:

- continuation of the physics programme (Faculty of Physics)
- development and maintenance of visualization software (Faculties of Physics, Mathematics and Information Science, Electronics and Information Technology)
- maintenance of DCDB

Possibilities:

- ALICE is planned to operate at least until 2026 with scheduled detector, computing and electronics upgrades
- redesign and upgrade of the detectors every couple of years
- detector R&D – material sciences
- redesign and upgrade of the electronics and computer system every couple of years

WARSAW UNIVERSITY OF TECHNOLOGY
OPPORTUNITIES FOR STUDENTS AT CERN

ALICE

Possibilities:

CERN has number of programmes open for students from Member States at various level (from Bachelor to Ph.D.):

- Summer Student Programme (only 2 slots for Poland) – 2 months
- Technical Student Programme – 1.5 year
- Doctoral Student Programme – 3 years

Remarks:

- Summer Students can work in all aspects of CERN life.
- Technical and Doctoral Students - students specializing in Applied Physics, Engineering or Computing are eligible to apply.
- Students must be affiliated to the University.

Examples:

Two current CERN Doctoral Students from the Faculty of Physics who did their M.Sc. thesis in ALICE:

- Marcin Patecki – started 1^{st} November 2013 (Beam Department)
- Jeremi Niedziela – Doctoral student from 1^{st} April 2014
  Working on the new event display and the QA and DQM for Run2 (2015) and Run3 (2019)

One current Technical Student in ALICE

- Adam Wegrzynek - Technical student from 1^{st} September 2013
  Working on a new web-based display for the future ALICE Run Control Center showing the data taking performance

More opportunities if co-funding

DELEGATION OF WARSAW UNIVERSITY OF TECHNOLOGY HAS VISITED CERN 2010

From left to right:

Prof. Tadeusz KULIK (vice Rector for Research), Prof. Franciszek KROK (vice Rector for Education), Prof. Rajmund BACEWICZ (Dean of Physics Faculty), Jurgen SCHUKRAFT (former AL[illegible] spokespers[illegible] Dr. Andrzej SIEMKO

Time for a new visit!!!

VISIT OF PRESIDENT OF FOUNDATION FOR POLISH SCIENCE AT CERN 2013

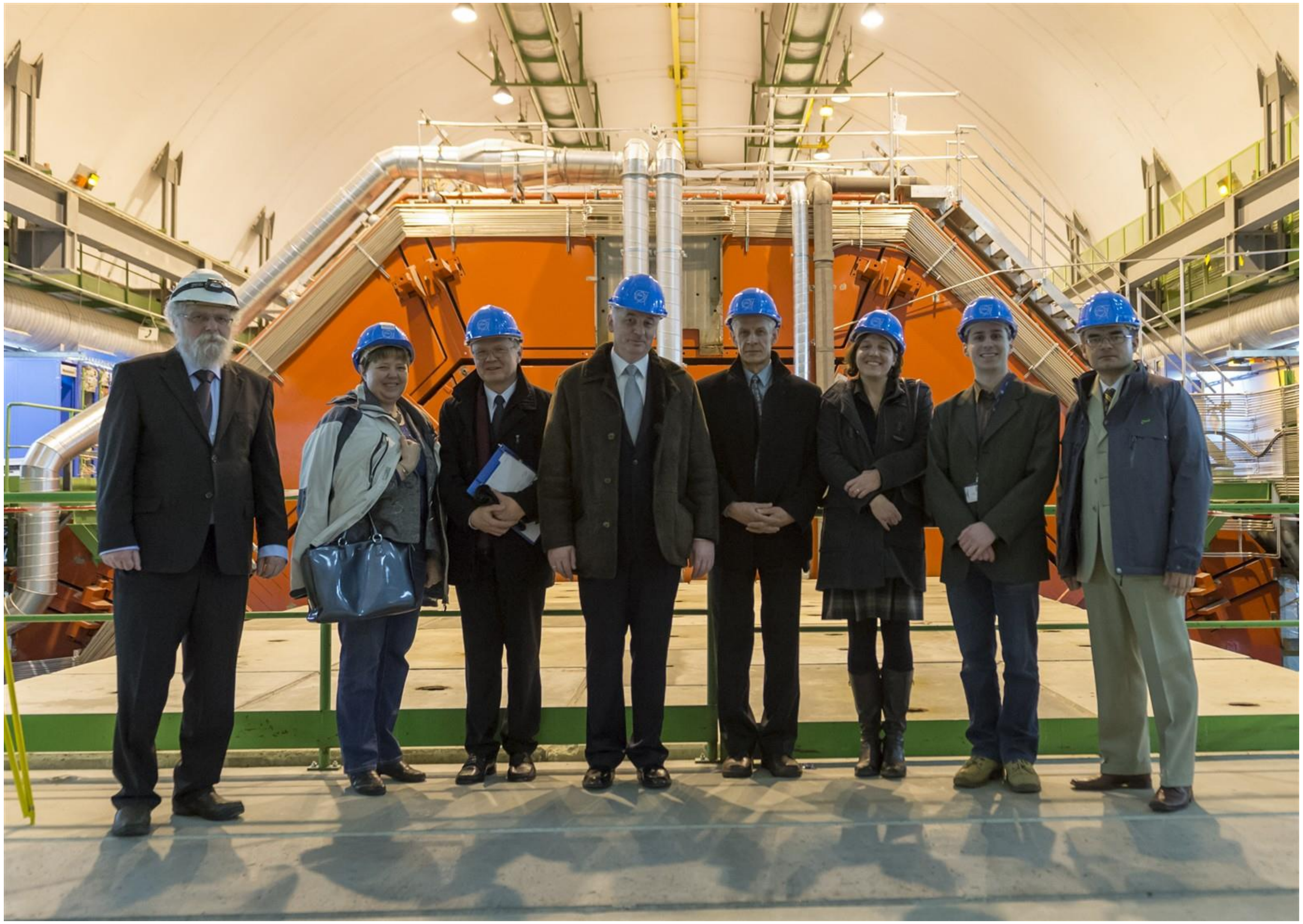
Prof. Maciej Zylicz

and the accompanying persons

at the cavern

of ALICE

detector



ALICE AND POLAND

Exhibition:

"LHC – How does it work?" in Poland 2008/2009

→Travelling exhibition around Poland

Main organizers: Jan Grabski, Jan Pluta and Marek Pawlowski

A large multimedia and interactive exhibition "**LHC – how does it work?**" was prepared by the Faculty of Physics, Warsaw University of Technology and by many other institutions participating in the LHC program in Poland and working with various applications of nuclear physics.

The exhibition was presented for the first time in November 2008 at the Faculty of Physics, Warsaw University of Technology.
Later on was presented in 12 other Polish towns.

The exhibition was visited by more than 50000 persons; a half of them in guided groups. Many thousands of young people participated in the competitions.

LHC exhibition in Poland in 2009

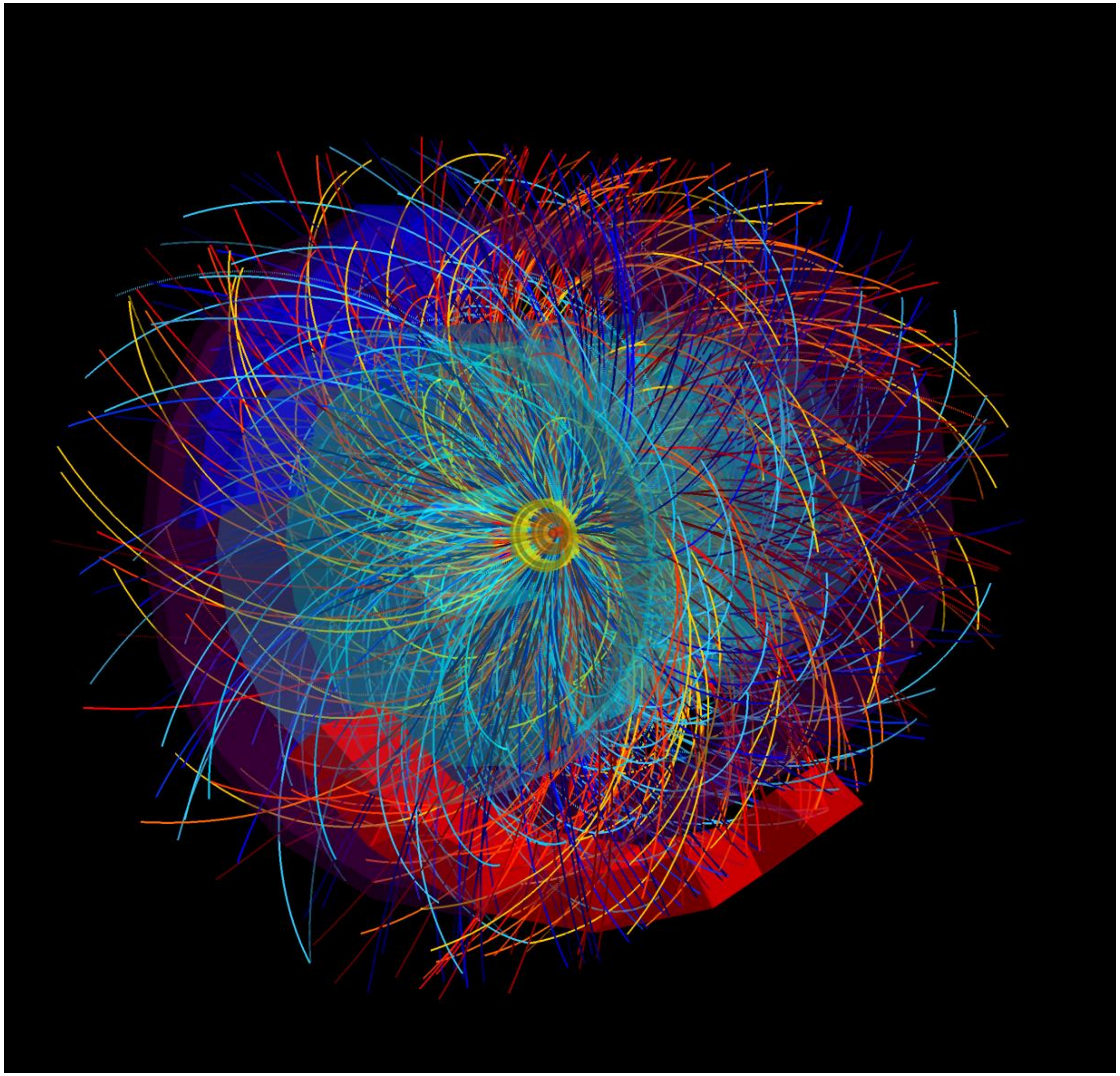
„LHC – How does it work?”

→One week visits in 13 places
Finances:
80.000€ as a Science Council grant
12.000€ Sponsors
+ 2.500€ - 12.000€ local organisers for each event

Local communities of physicists (not necessary particle physicists) were involved in organization and presentations.

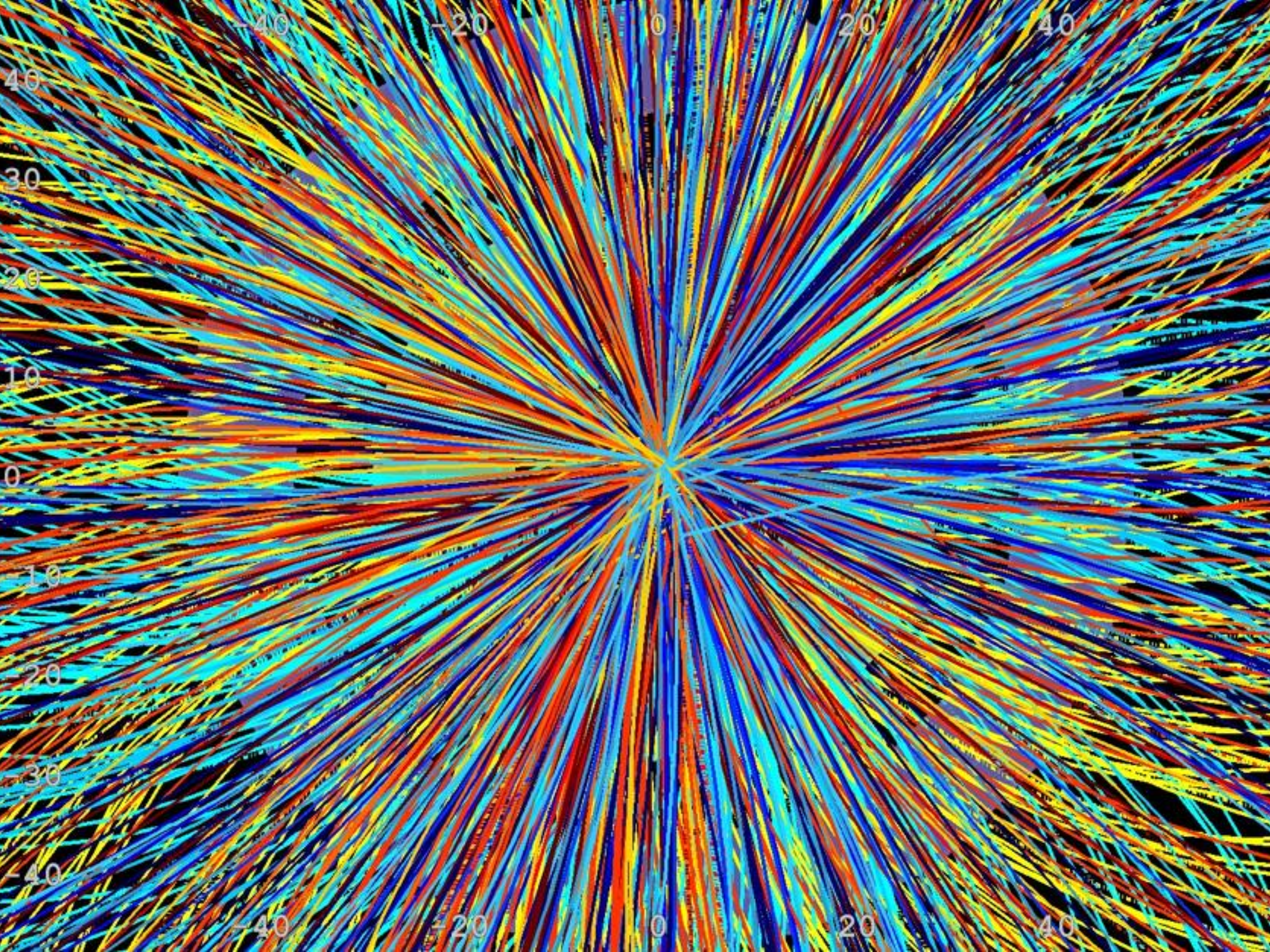
Vizulisation of Pb+PB collisions registered by ALICE were presented in the internatonal scientific journals and newspapers.

Visualisation was made by the student of Warsaw University of Technology – Pawel Debski.



Conclusion

- ALICE is a very exciting project, with a long and rich future!
- Lots of opportunities for all types of expertise
- Great opportunity for training in both science and technology
- ***A long history of successful collaboration with WUT!***
- ***We count on Poland in general and WUT in particular to play a key role in the project!!***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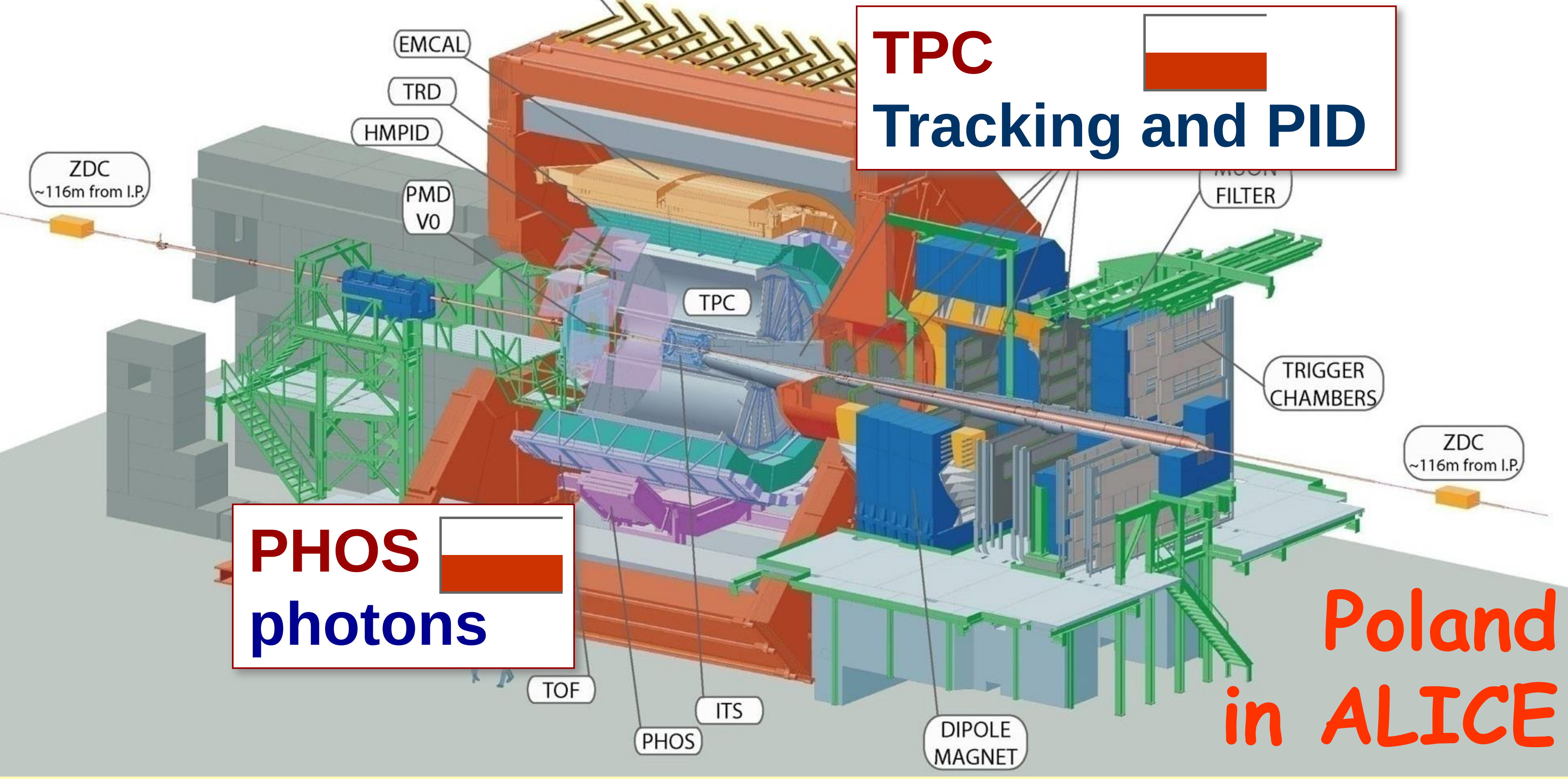

- **At the core of the technology:**

Sub-detectors:

Time Projection Chamber

Photon Spectrometer

Detector Construction Data Base (DCDB):

Poland's team created the DCDB and is now responsible for its operation

- **At the core of the Physics:**

Data Analysis:

Poland participates to the activity of the **PWG-CF** (Correlations & Fluctuasions), Adam KISIEL is a convenor of the Femtoscopy PAG group.

Also active in UPC studies

A long way...

- Hagedorn 1965: mass spectrum of hadronic states $\rho(m) \propto m^{\alpha} \exp(m/B)$
  => Critical temperature T_c=B
- QCD 1973: asymptotic freedom
  – D.J.Gross and F.Wilczek, H.D. Politzer
- 1975: asy … q… and gluons

Prize motivation: "for the discovery of asymptotic freedom in the theory of the strong interaction"

Nobel Prize in Physics 2004

David J. Gross H. David Politzer Frank Wilczek

The ALICE O2 Hardware System