Welcome

Добро пожаловать

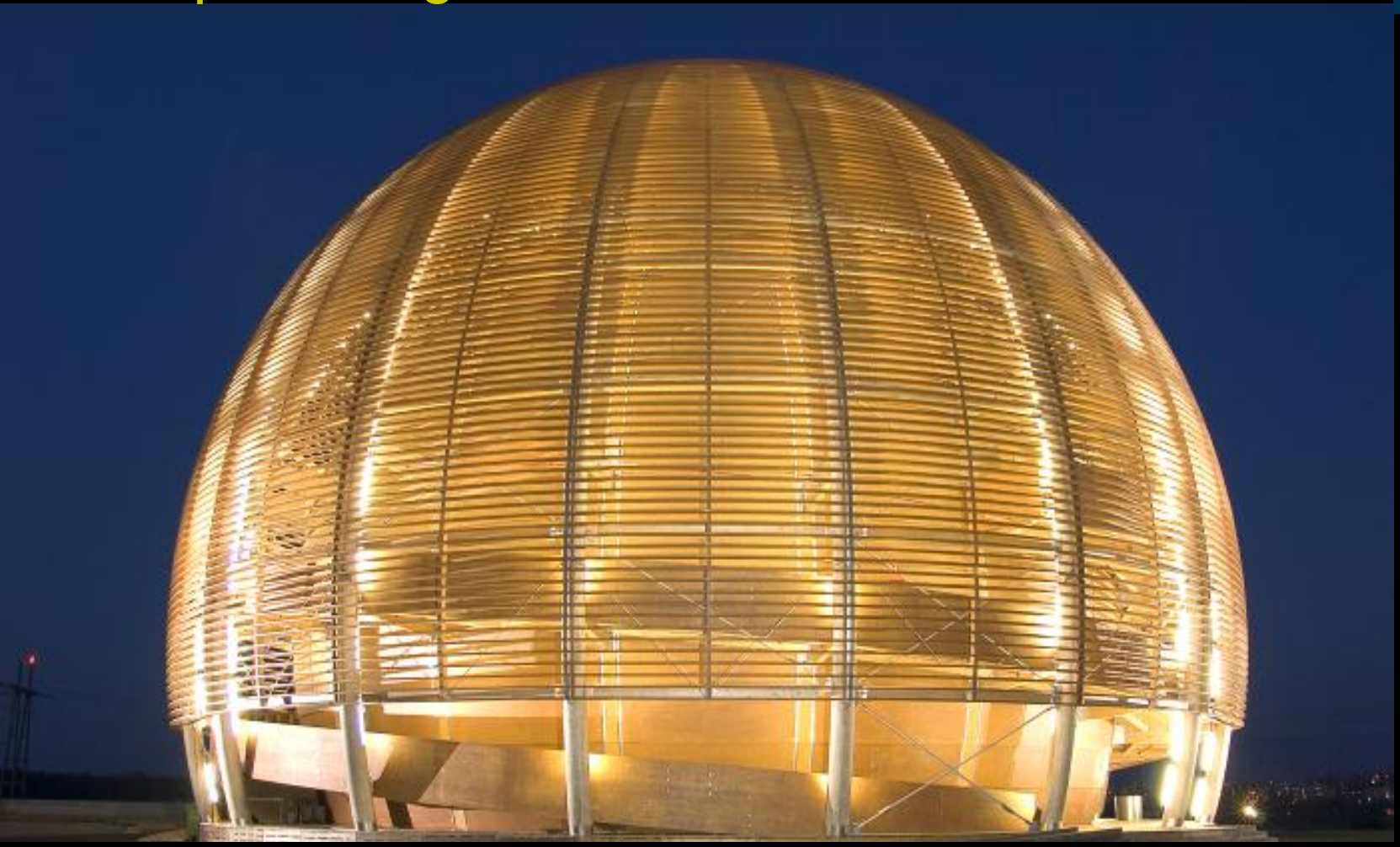
Third Russian Teachers Programme

October-November 2011

Accelerating Science and Innovation

Introduction to CERN

European Organization for Nuclear Research



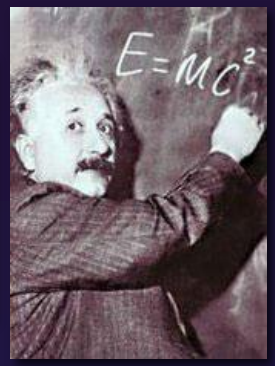
Tadeusz KURTYKA – CERN - Projects Office of Accelerator Sector / International Relations Office

Innovation
Education
CERN
uniting people
Research

The Mission of CERN

- **Push forward** the frontiers of knowledge

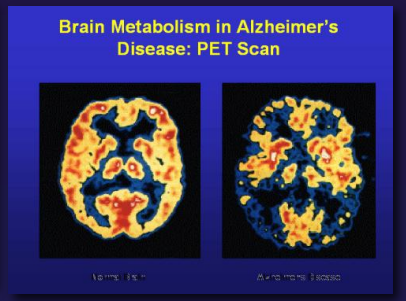
  E.g. the secrets of the Big Bang …what was the matter like within the first seconds of the Universe's life?



- **Develop** new technologies

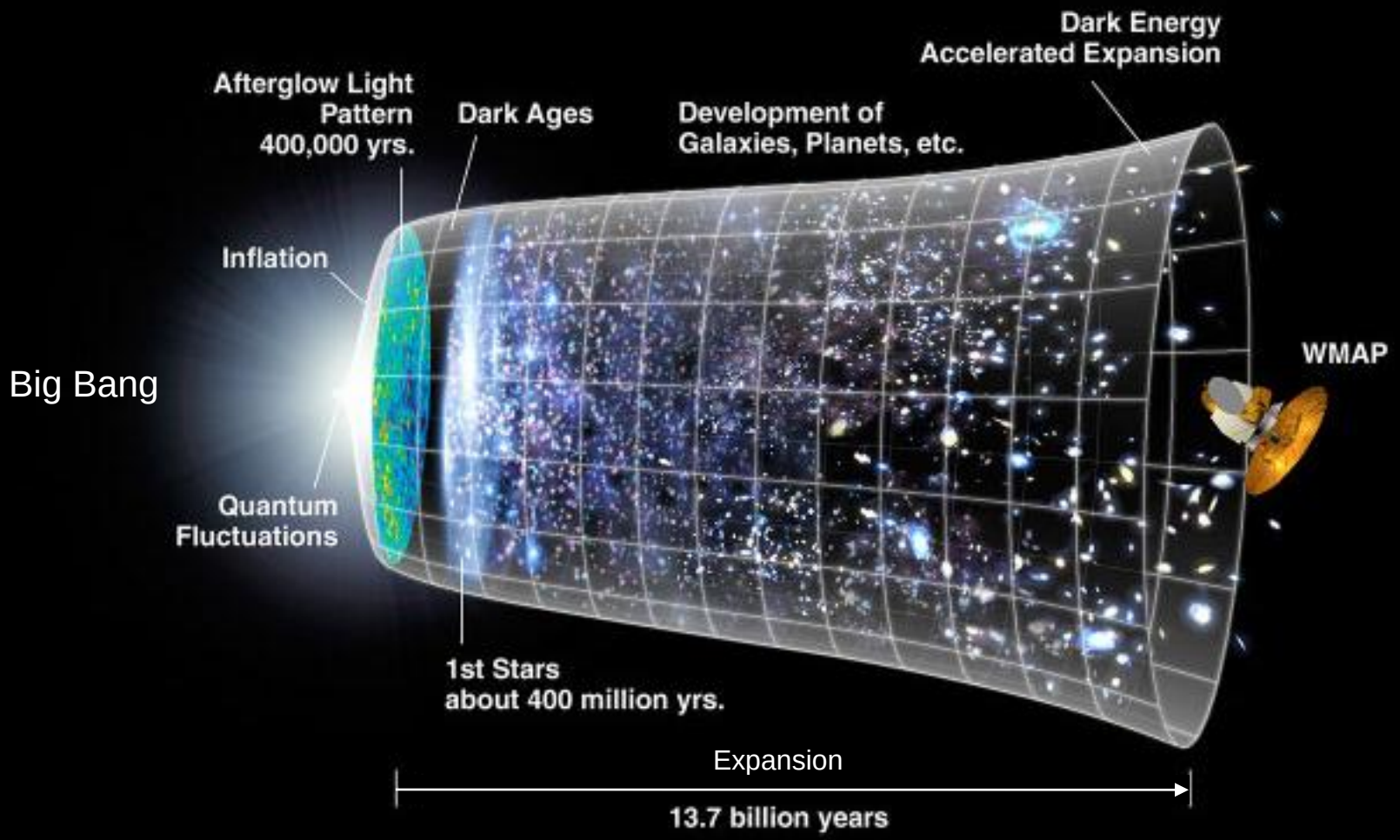
  Information technology - the Web and the GRID

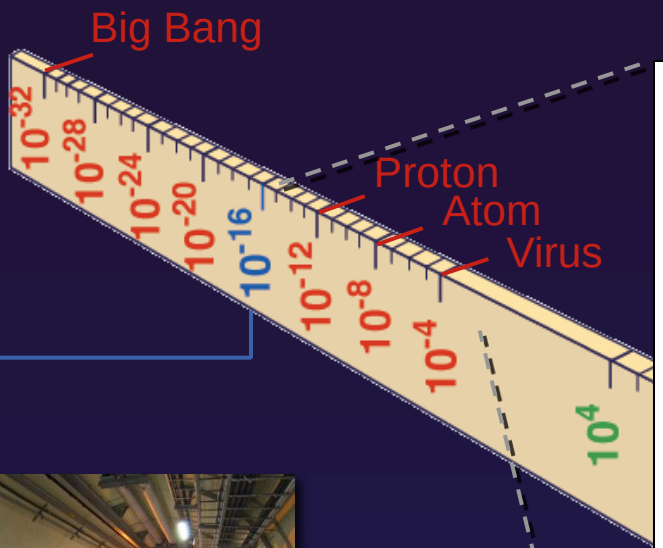
  Medicine - diagnosis and therapy

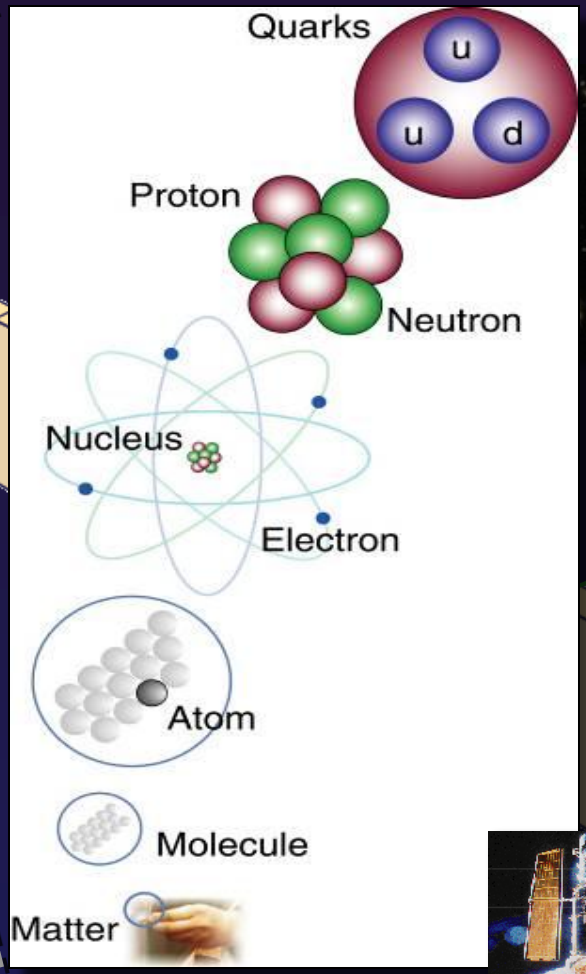


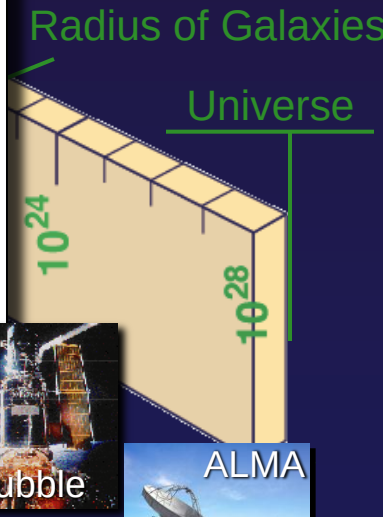
- **Train** scientists and engineers of tomorrow

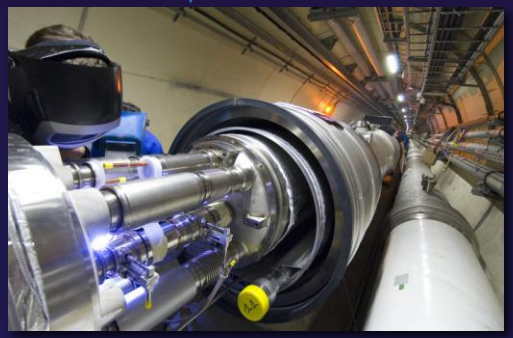
- **Unite** people from different countries and cultures


Dark Energy
Accelerated Expansion
Afterglow Light
Pattern
400,000 yrs.
Dark Ages
Development of
Galaxies, Planets, etc.
Inflation
Big Bang
WMAP
Quantum
Fluctuations
1st Stars
about 400 million yrs.
Expansion
13.7 billion years









LHC

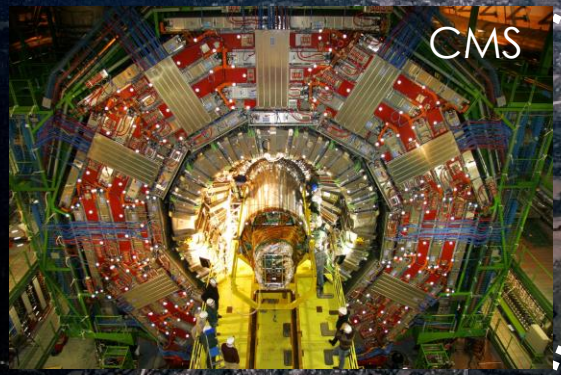
Super-Microscope

Study physics laws of first moments after Big Bang

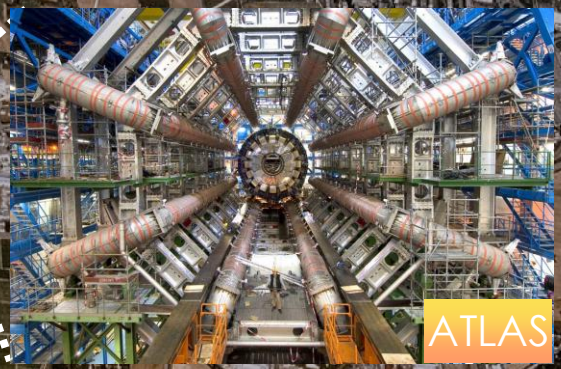
↙ increasing Symbiosis between Particle Physics, Astrophysics and Cosmology

Enter a New Era in Fundamental Science

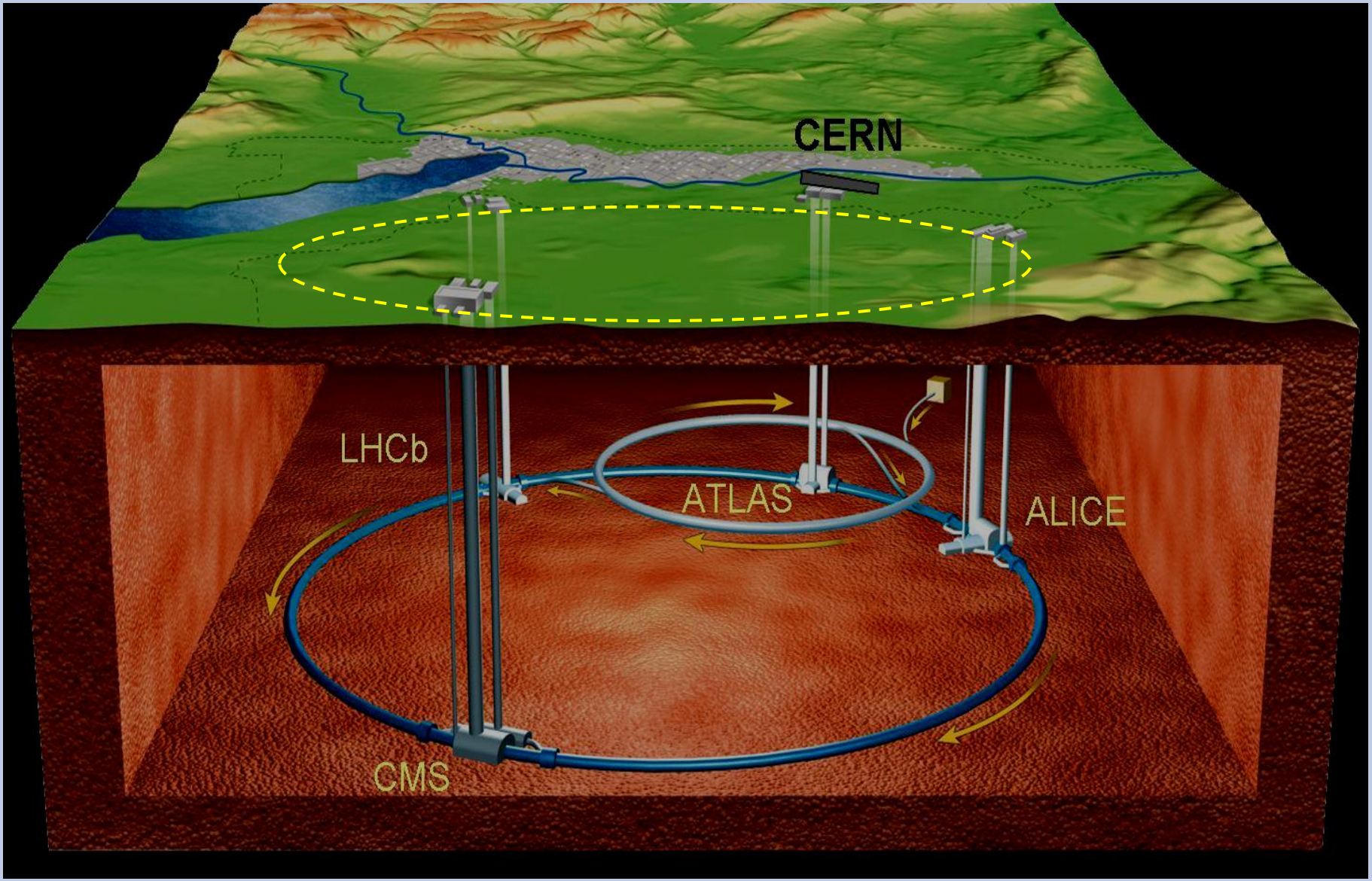
Large Hadron Collider (LHC), one of the largest and truly global scientific projects ever, is the most exciting turning point in particle physics.



Exploration of a new energy frontier
Proton-proton collisions at E_{CM} = 14 TeV

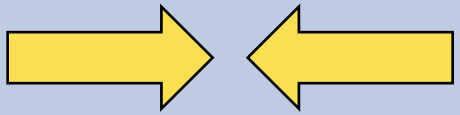


LHC – Large Hadron Collider



LHC - Large Hadron Collider

7 TeV + 7 TeV



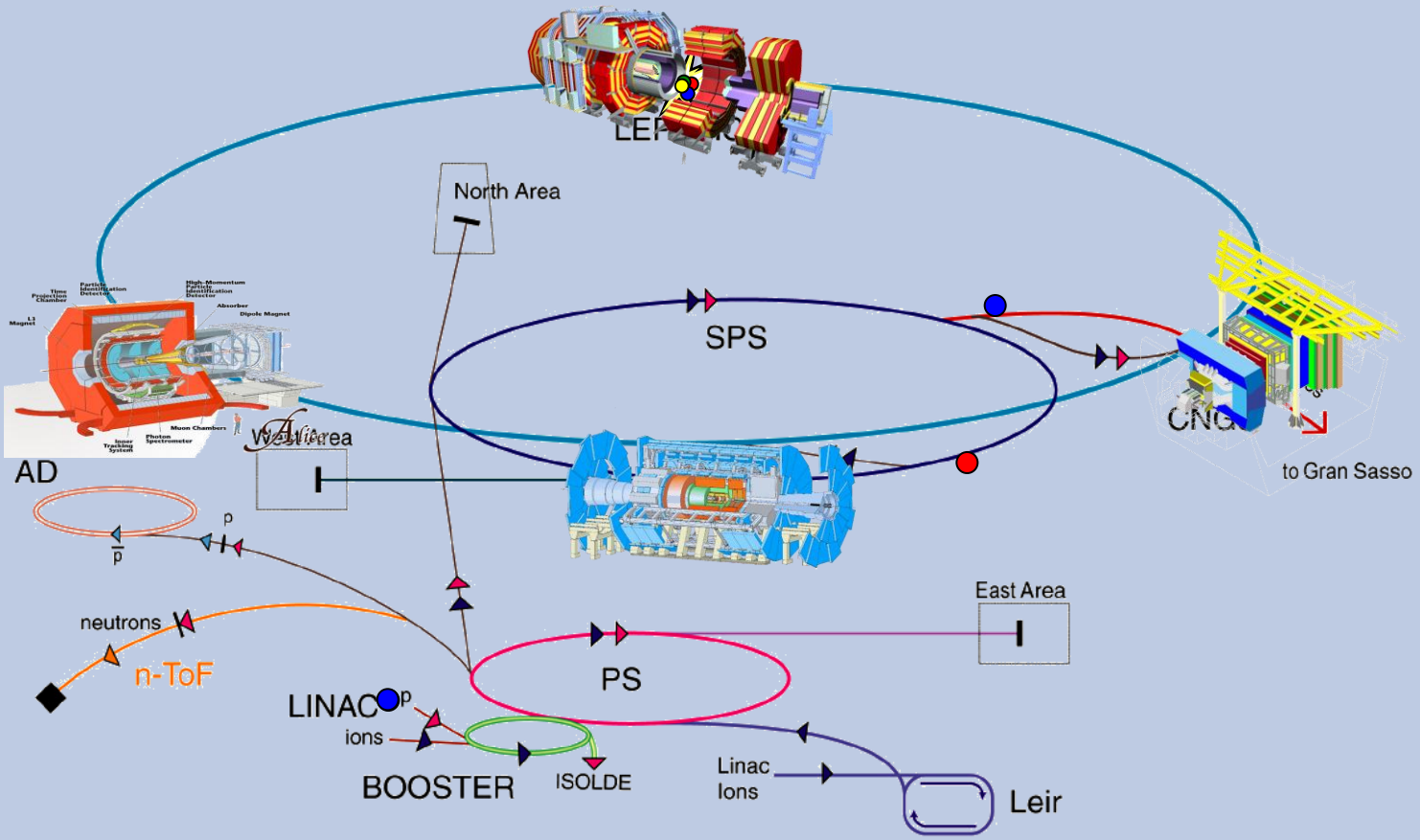
Luminosity = $10^{34}cm^{-2}sec^{-1}$

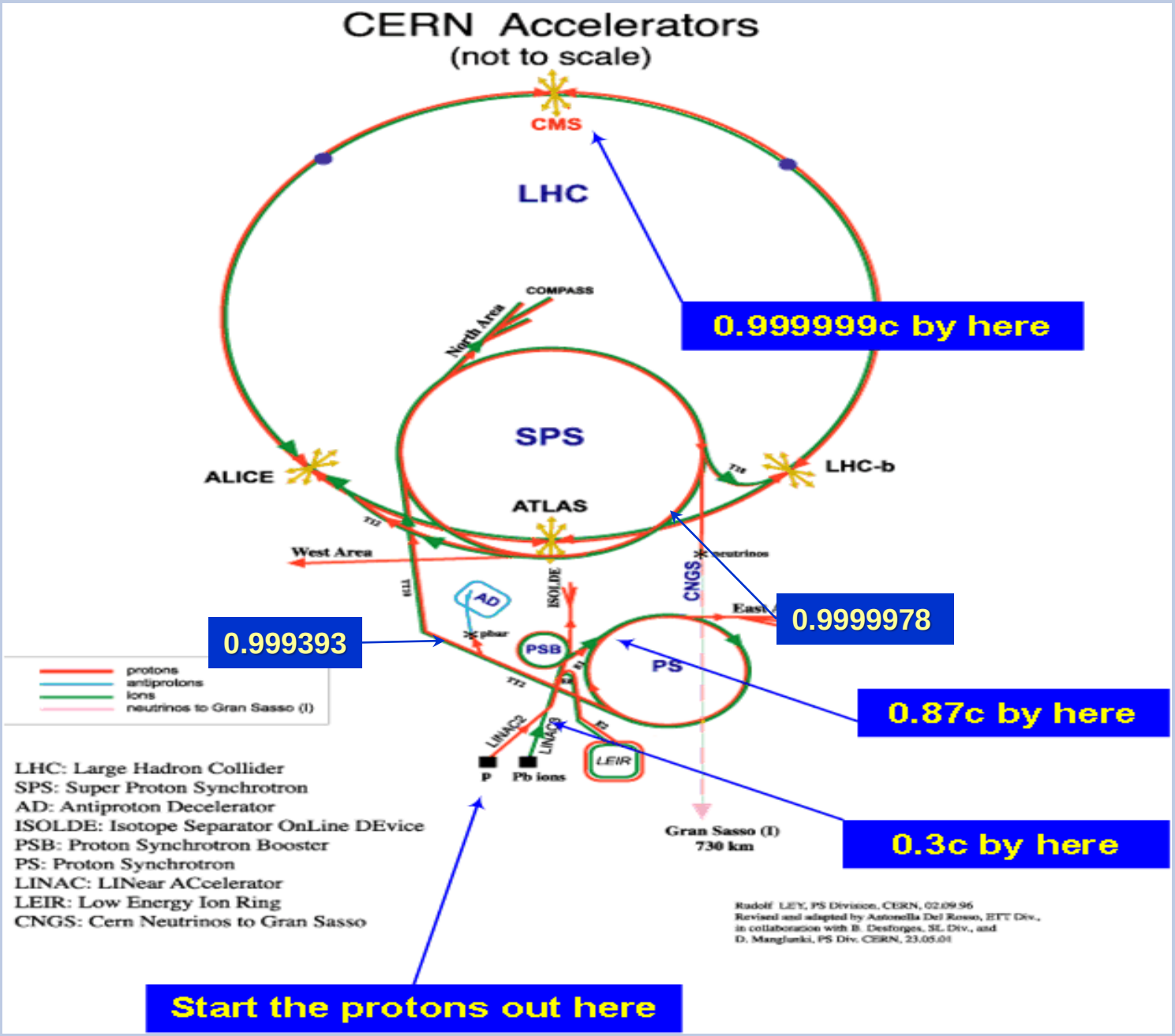
Primary targets:
- Origin of mass
- Nature of Dark Matter
- Primordial Plasma
- Matter vs Antimatter

The LHC results will determine the future course of High Energy Physics

The large Hadron Collider

Collision of proton beams… …observed in giant detectors




CERN Accelerators
(not to scale)
CMS
LHC
COMPASS
North Area
SPS
ALICE
ATLAS
LHC-b
West Area
CNGS
neutrinos
East
AD
ISOLDE
PSB
PS
LINAC2
LINAC3
LEIR
p
Pb ions
Gran Sasso (I)
730 km
protons
antiprotons
ions
neutrinos to Gran Sasso (I)
LHC: Large Hadron Collider
SPS: Super Proton Synchrotron
AD: Antiproton Decelerator
ISOLDE: Isotope Separator OnLine DEvice
PSB: Proton Synchrotron Booster
PS: Proton Synchrotron
LINAC: LINear ACcelerator
LEIR: Low Energy Ion Ring
CNGS: Cern Neutrinos to Gran Sasso
Rudolf LEY, PS Division, CERN, 02.09.96
Revised and adapted by Antonella Del Rosso, ETT Div.,
in collaboration with B. Desforges, SL Div., and
D. Manglunki, PS Div. CERN, 23.05.01
0.999999c by here
0.9999978
0.999393
0.87c by here
0.3c by here
Start the protons out here

LHC Magnets

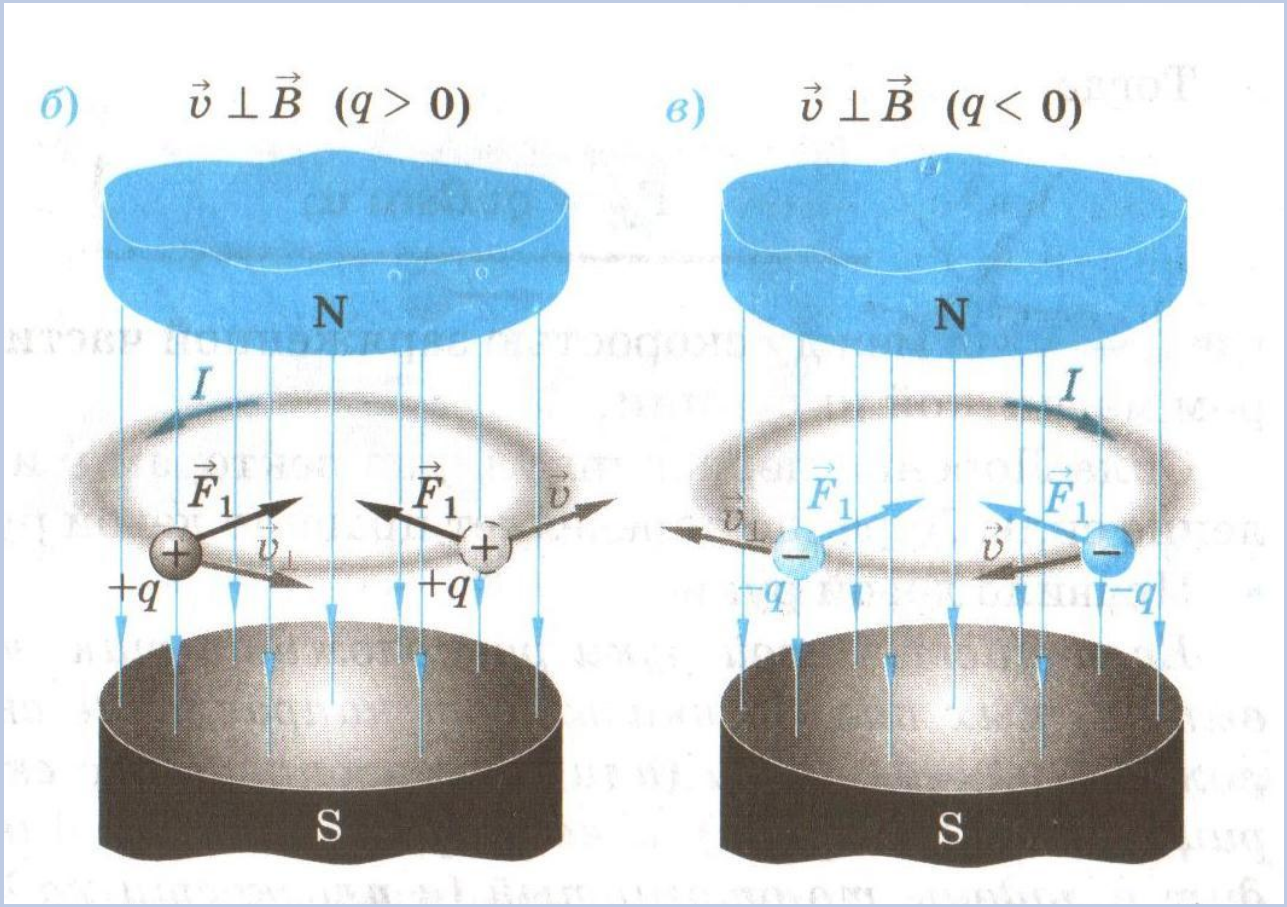
- **A. Accelerator magnets**
  - Bending magnets (dipoles)
  - Focusing magnets (quadrupoles)
  - Correction magnets

LHC Magnets

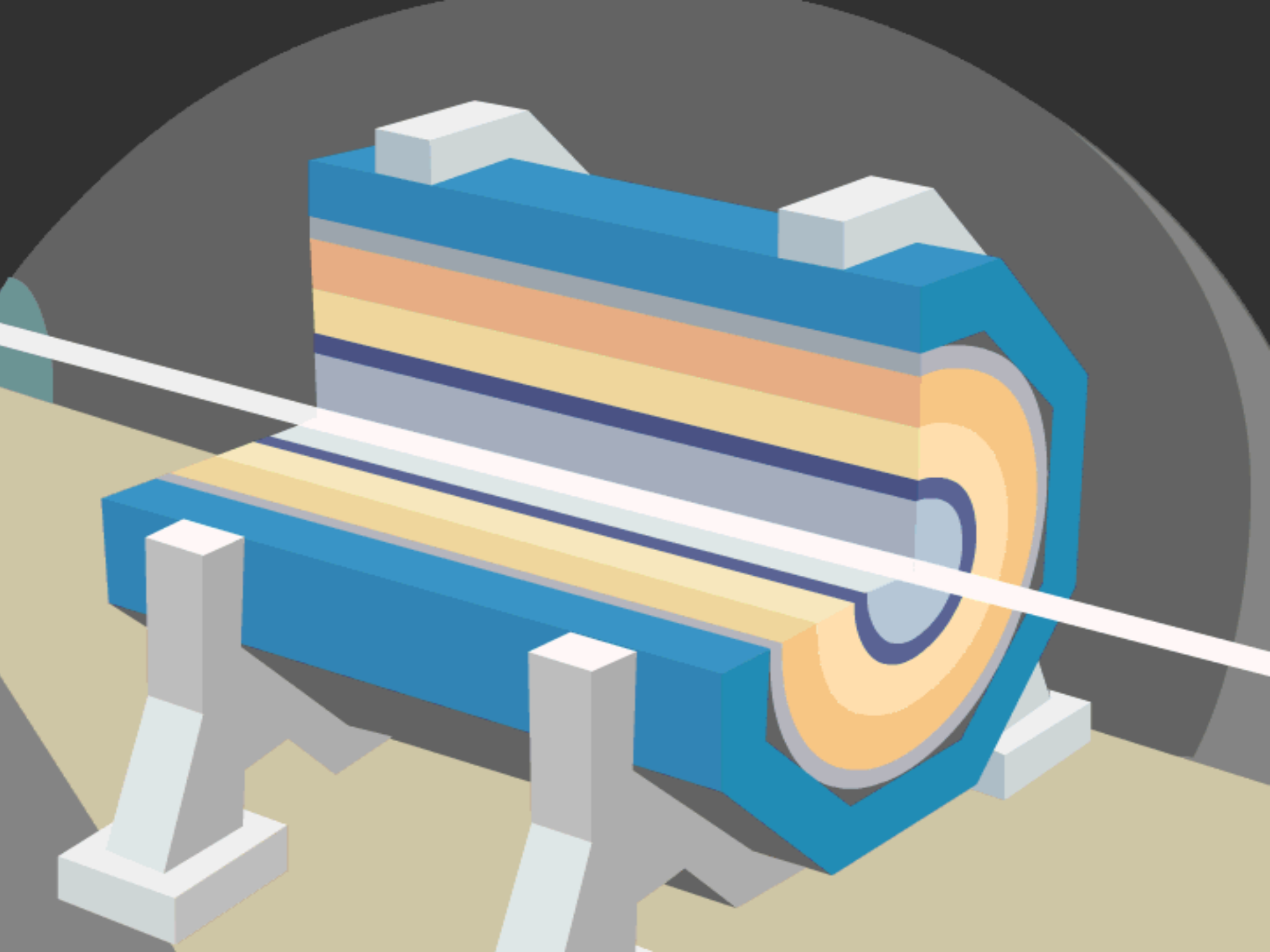
- 1. Dipole magnets are bending the trajectory of particles (keep them on circular trajectory)

Problem no.1

Calculate the magnetic field B necessary to keep the protons of the energy E= 7 TeV on a (nearly) circular trajectory of the LHC ring (approx. radius R = 4.3.km), knowing that at this energy the protons will have the speed v=99.9999991% of speed of light c


б) $\vec{v} \perp \vec{B}$ $(q > 0)$
в) $\vec{v} \perp \vec{B}$ $(q < 0)$
N
S
I
$\vec{F}_1$
$\vec{v}$
$\vec{v}_\perp$
+q
−q

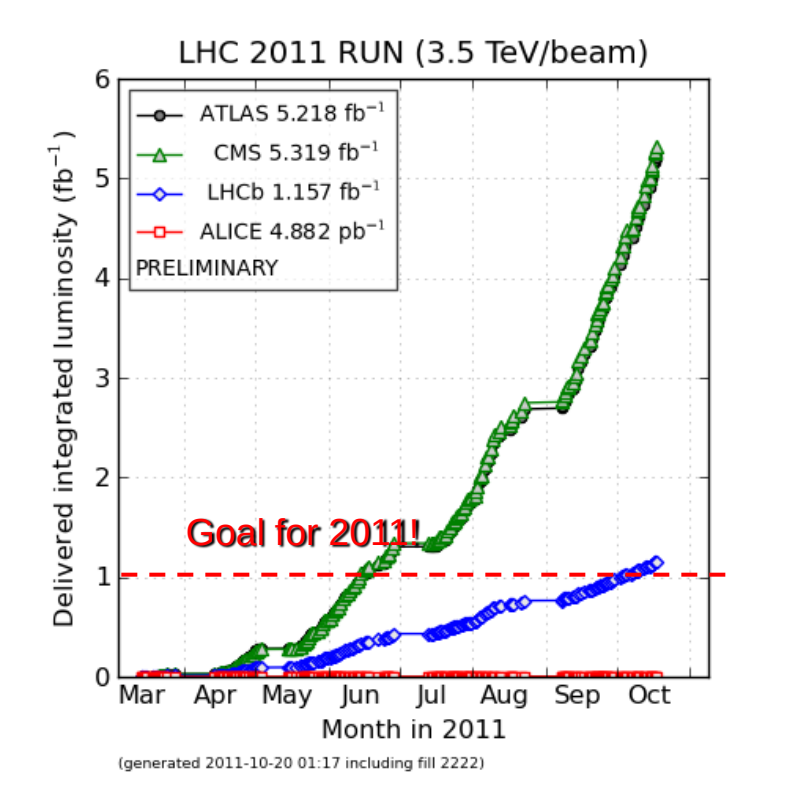
$$R = \frac{mv}{qB}$$

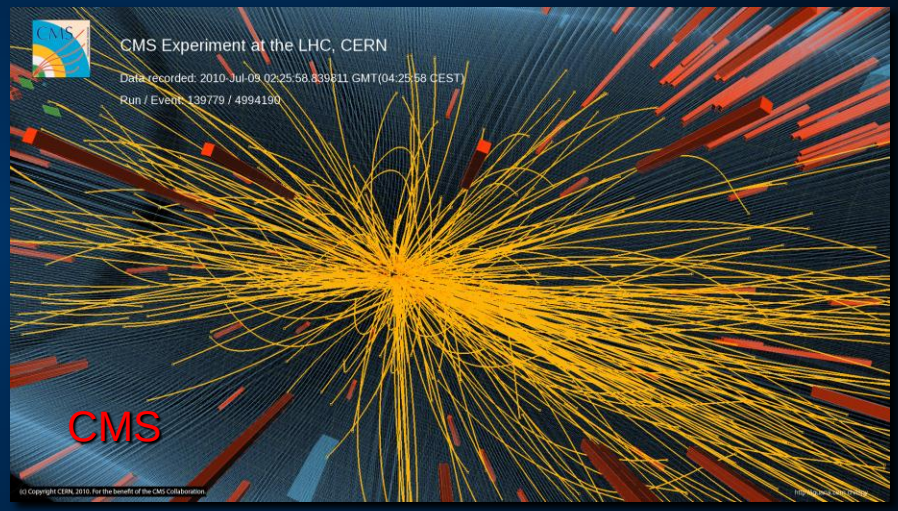


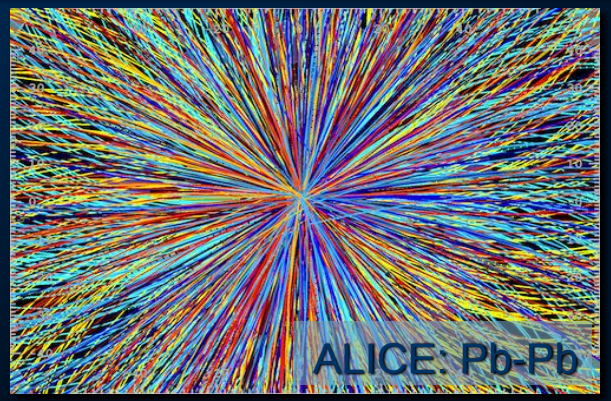
LHC + Experiments: spectacular start-up in 2010

First p-p collisions at √s = 7 TeV on 30 March 2010, restart 13 March 2011
First Pb-Pb collisions on 7 Nov 2010

→ Brilliant performances of LHC, experiments and computing

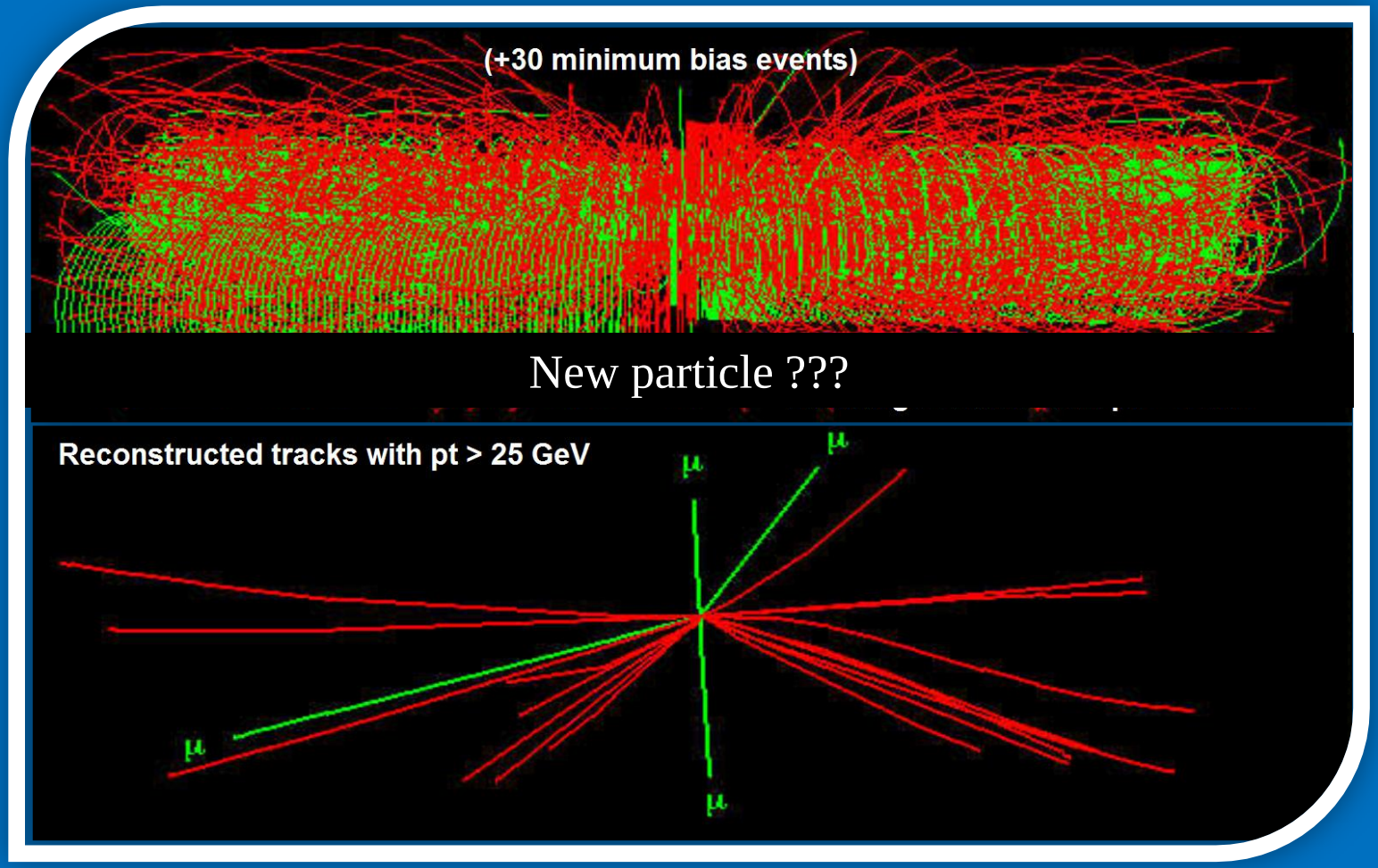




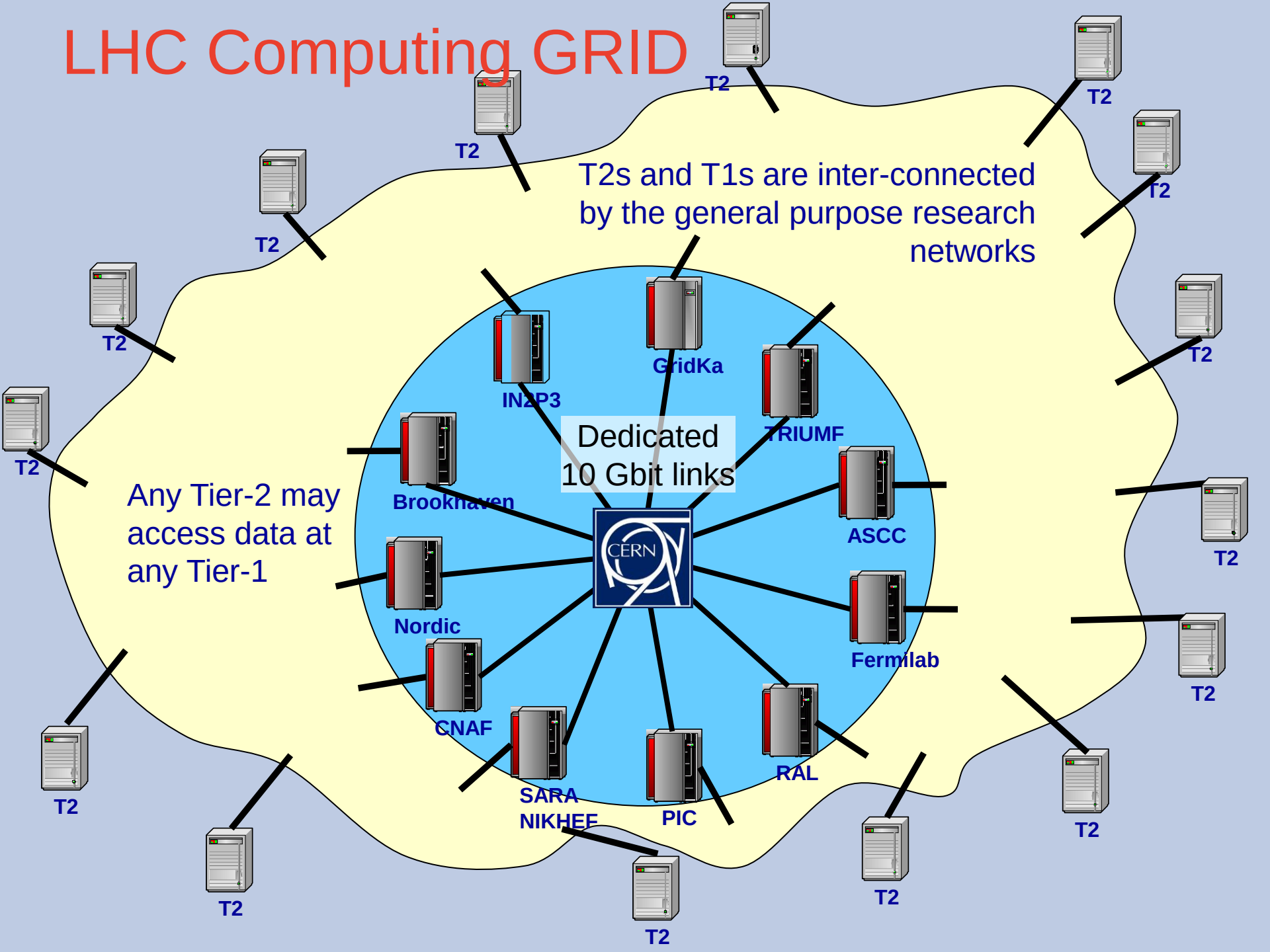


Impressive detector performances

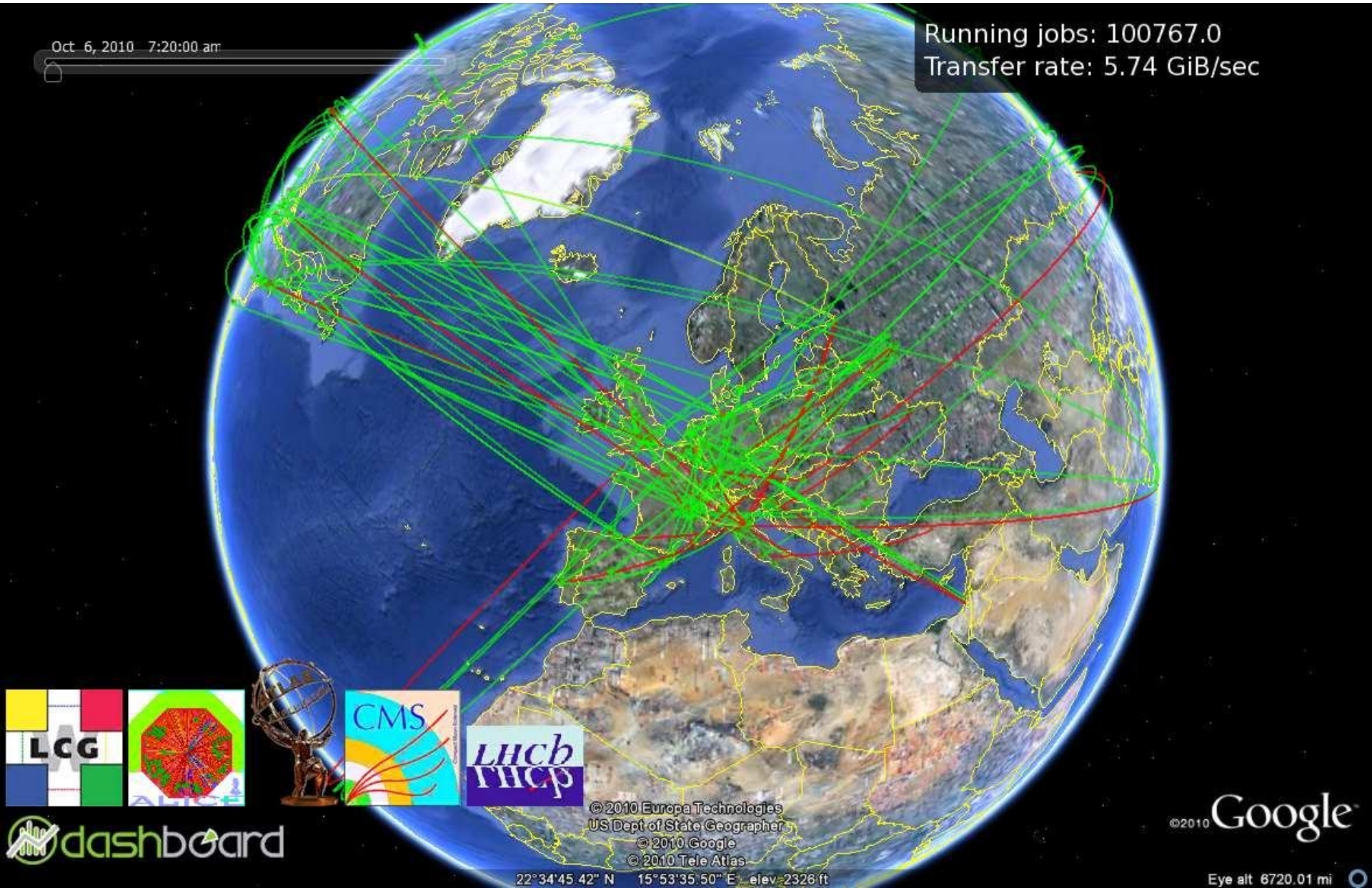
Searching for new particles requires selection and analysis of enormous quantity of data from LHC detectors



LHC Computing GRID



LHC Computing GRID



Three main challenges of the LHC Project

First: Construct a 2x7 TeV proton collider using existing tunnel of 27 km circumference (tunnel diameter 3.8 m). **Solution:** Innovative design of superconducting magnets bending the beam to the tunnel radius, and cooled with superfluid helium.

Second: Construct detectors with unprecedented granularity, dimensions and rapidity of registration. **Solution:** Innovative detector types, new materials, giant superconducting magnets, fast electronics for events registration….

Third: Develop a new computing system to handle an analyze enormous amount of data. . **Solution:** LCG – LHC Computing GRID – distributed computing concept.

ALL THE THREE REQUIRED GLOBAL COLLABORATION !

CERN was founded in 1954: 12 European States

"Science for Peace"

Today: 20 Member States

~ 2300 staff
~ 790 other paid personnel
> 10000 users

Budget (2011) ~1000 MCHF

20 Member States: Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom

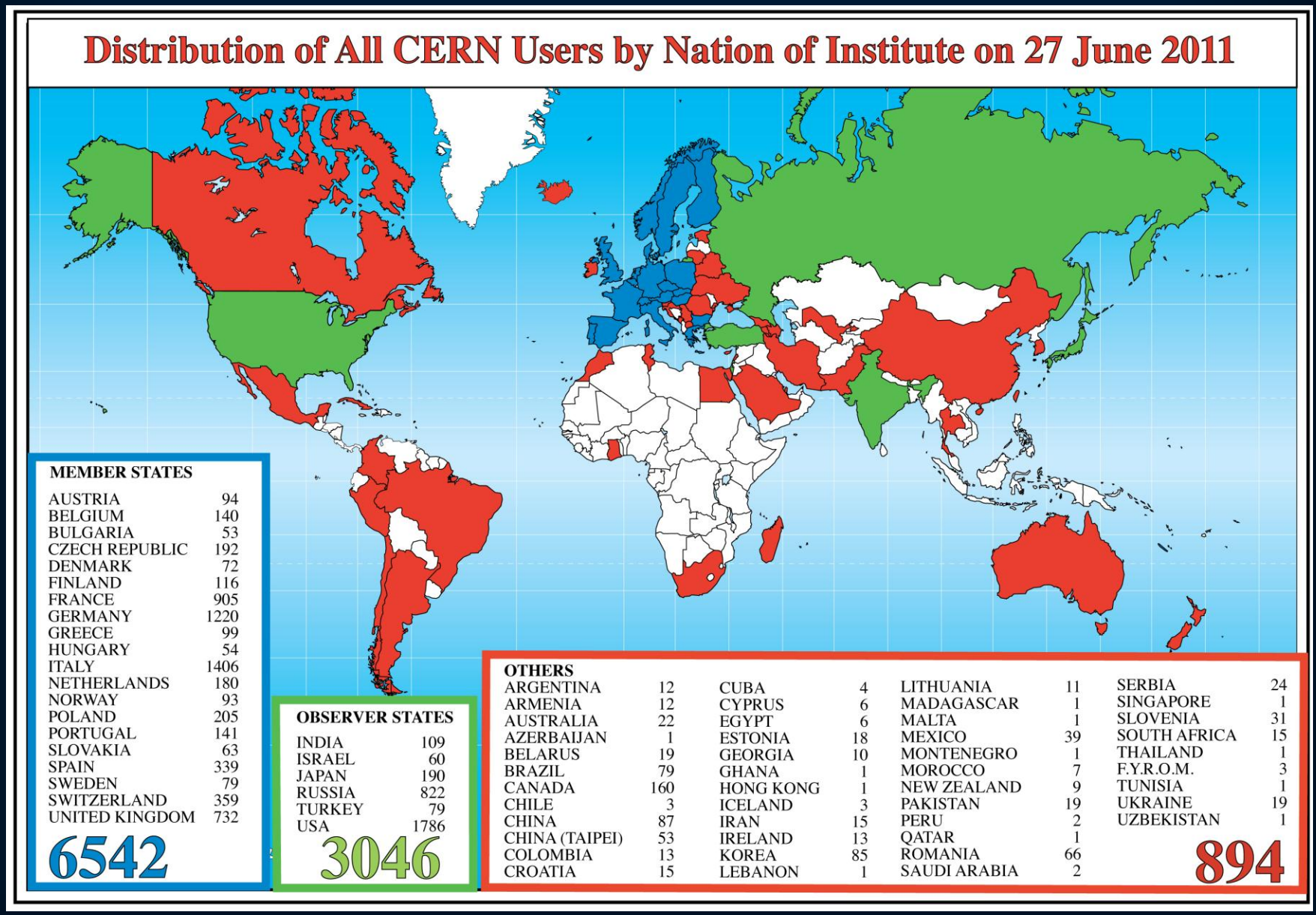
1 Candidate for Accession: Romania

1 Associate Member State: Israel (since 12 October 2011)

4 Applicant States: Cyprus, Serbia, Slovenia, Turkey

8 Observers to Council: India, Israel, Japan, the Russian Federation, the United States of America, Turkey, the European Commission and UNESCO

Science is getting more and more global



Participation of Non-Member States in CERN scientific programmes

- **CERN is financed by 20 Member States, with annual contributions proportional to the Net National Income (or GDP), but has scientific and educational links with nearly 100 countries!**
- **Non-Member States participate in financing selected Projects**
- **Over 40 Non-Member States participated in the LHC construction, providing around 1/6 th of its cost and over 3000 of physicists and engineers (over 1/3 of the total);**

Contribution of CIS countries to LHC

(CIS - Содружество Независимых Государств, СНГ)

Important contribution of the Russian Federation

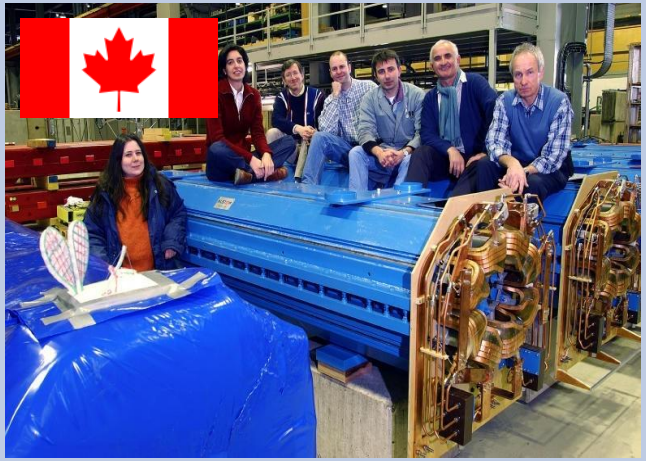
Highly appreciated contribution of other CIS countries.

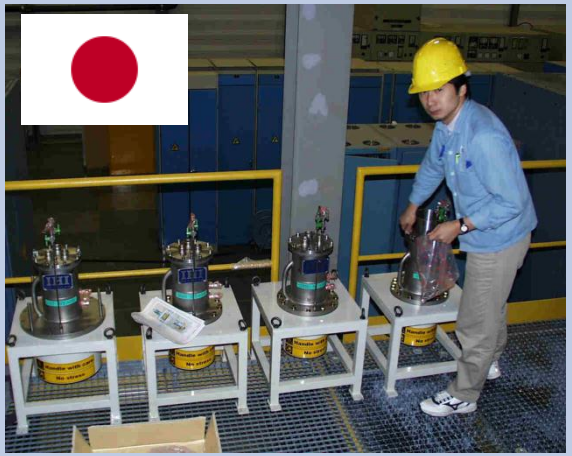
Important role of JINR - Dubna in creating LHC collaborations with CIS countries →

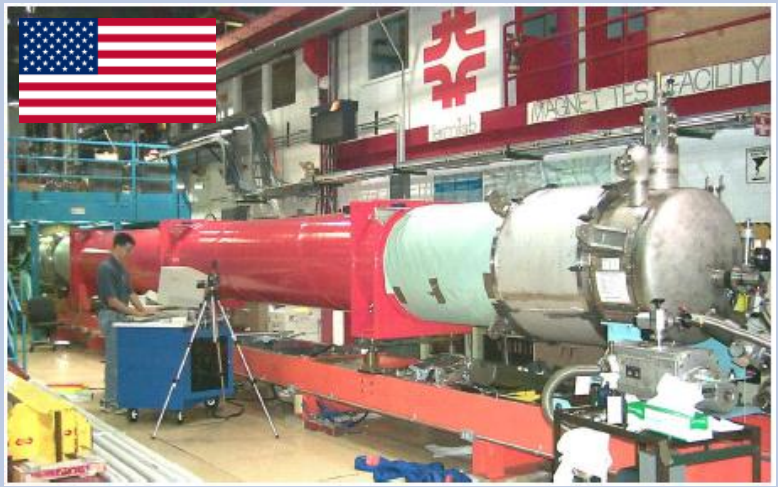
Armenia, Azerbaijan, Belarus, Georgia, Ukraine

(and also other JINR Members!)

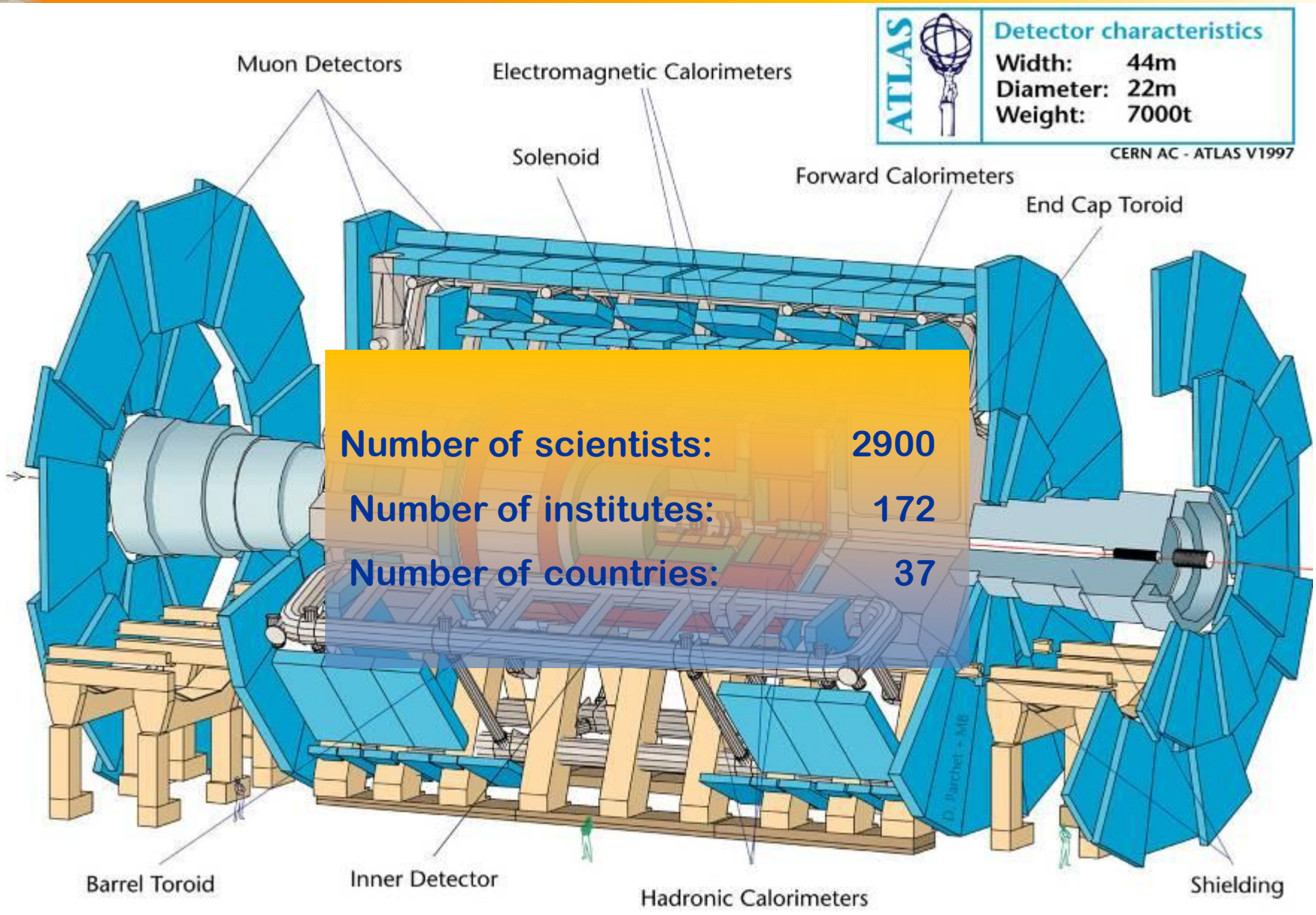
LHC Machine - Vital Contribution of Non-Member States: Canada, India, Japan, Russia, US







The ATLAS Detector (Spokesperson F. Gianotti)



Number of scientists: 2900

Number of institutes: 172

Number of countries: 37

Point 1 - UX15 vault demolition of central pillar - September 20, 2000 - CERN ST-CE

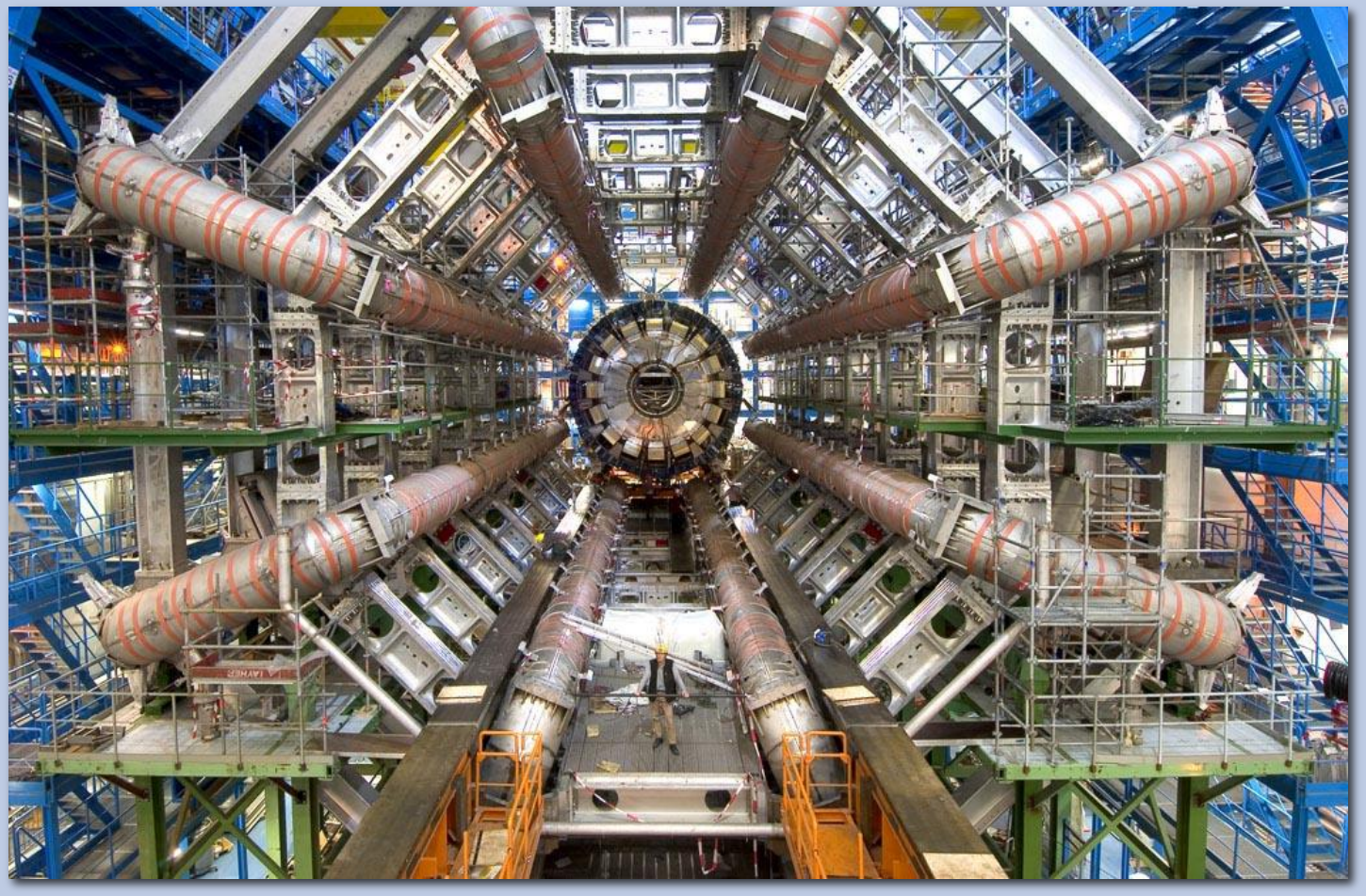
Point 1 - UX15 cavern - Concreting of vault panel n°2 - April 10, 2001 - CERN ST-CE

LHC Point 1 - UX 15 Cavern - Concrete walls 6th lift - 20-02-2003 - CERN ST-CE

Contribution of CIS countries to LHC

(CIS = Содружество Независимых Государств, СНГ)

Physicists and engineers from CIS countries have notably contributed to the construction of all LHC experiments (ATLAS, ALICE ,CMS, LHCb) and to the LHC accelerator



Unique Technologies developed for LHC

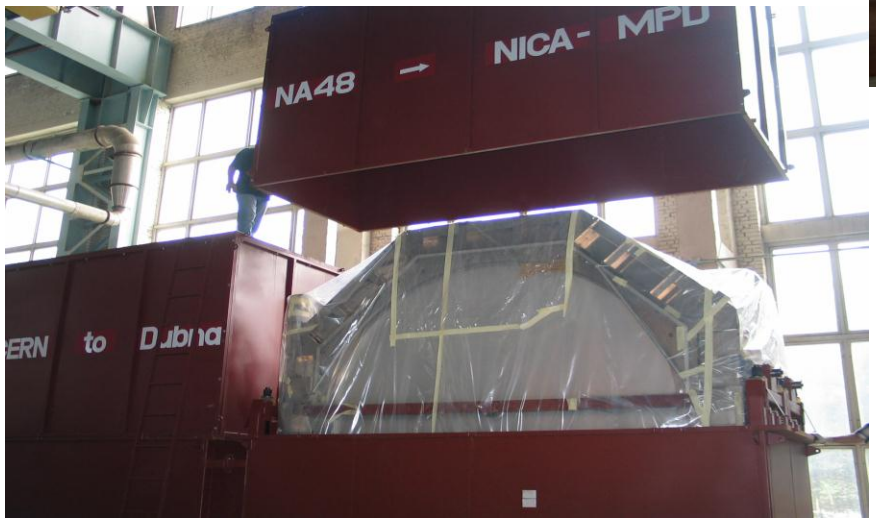
Example: SCINTILLATING CRYSTALS - monocrystals of PbWO4 developed and produced in Russia - the main elements (70’000 pieces!) in the Compact Muon Solenoid (CMS) detector at the CERN Large Hadron Collider (LHC)

CERN - JINR co-operation for NICA Project

CERN-JINR 2010 co-operation agreement signed

Common R&D on accelerators:

- Experimental studies of stochastic and electron cooling of ion bunched beam @ LEIR and Nuclotron;
- Problem of electron clouds in cyclic accelerators and ultra high vacuum technologies;
- Technologies of HV kickers and beam diagnostics of a high sensitivity.



CERN NA48 drift chambers as contribution to the NICA detector complex: delivered to Dubna

AIS and EVM systems:

AIS - for JINR, EVM - for NICA

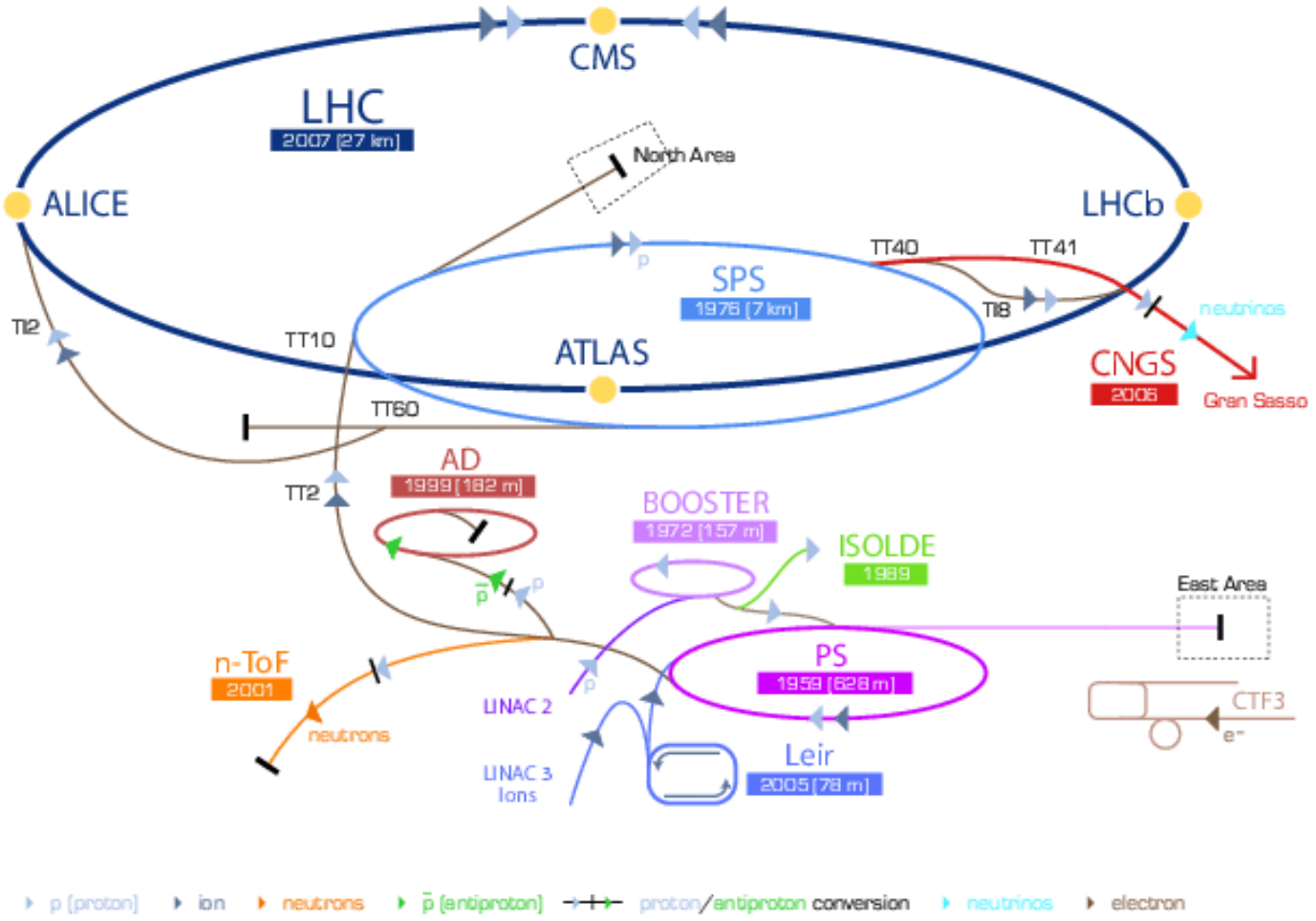
AIS: Administrative Information System

EVM: Earned Value Management

1st school JINR-CERN on EVM: Dubna, Oct 2010

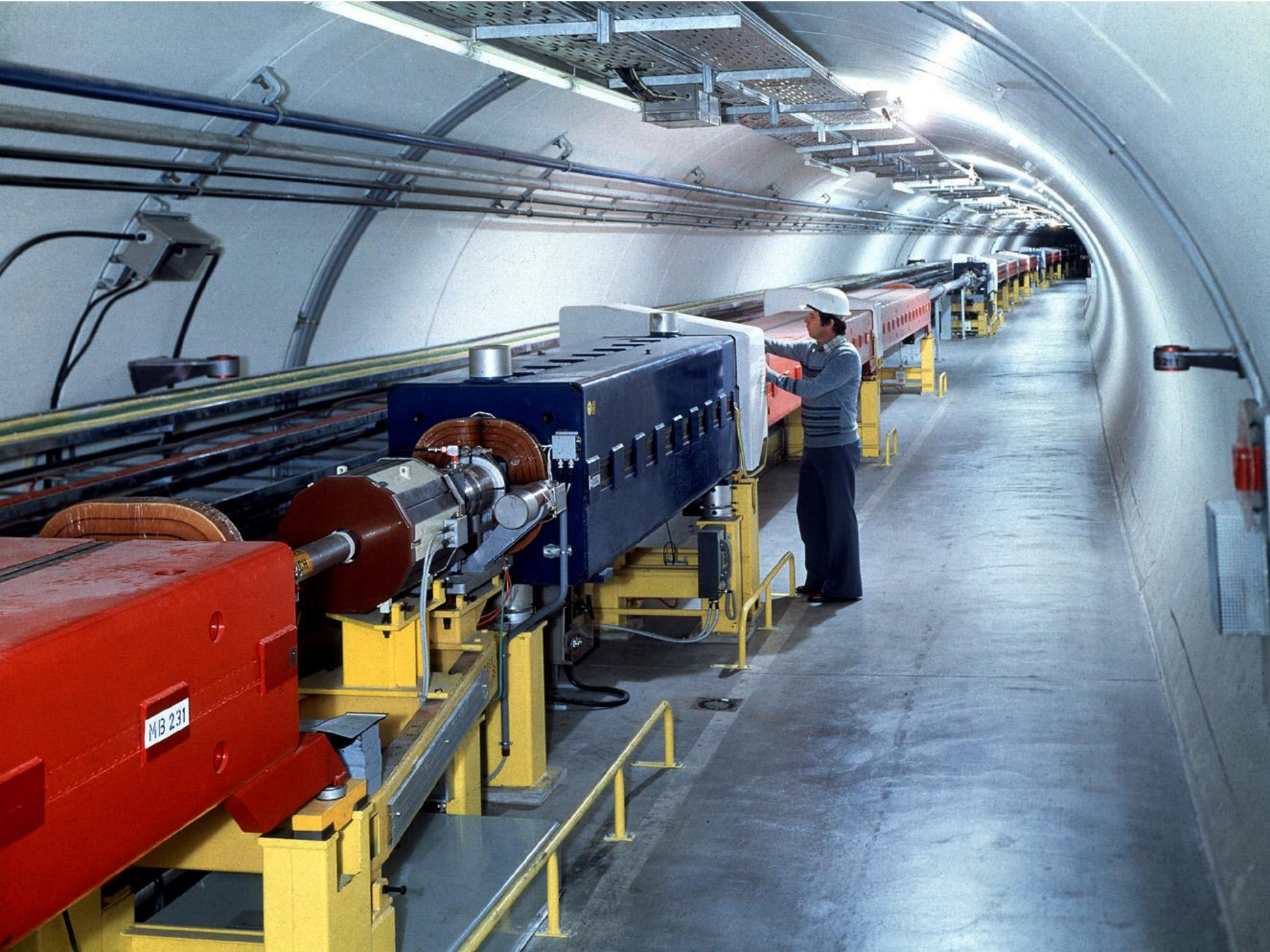
2nd school JINR-CERN on EVM: Dubna, Oct. 2011

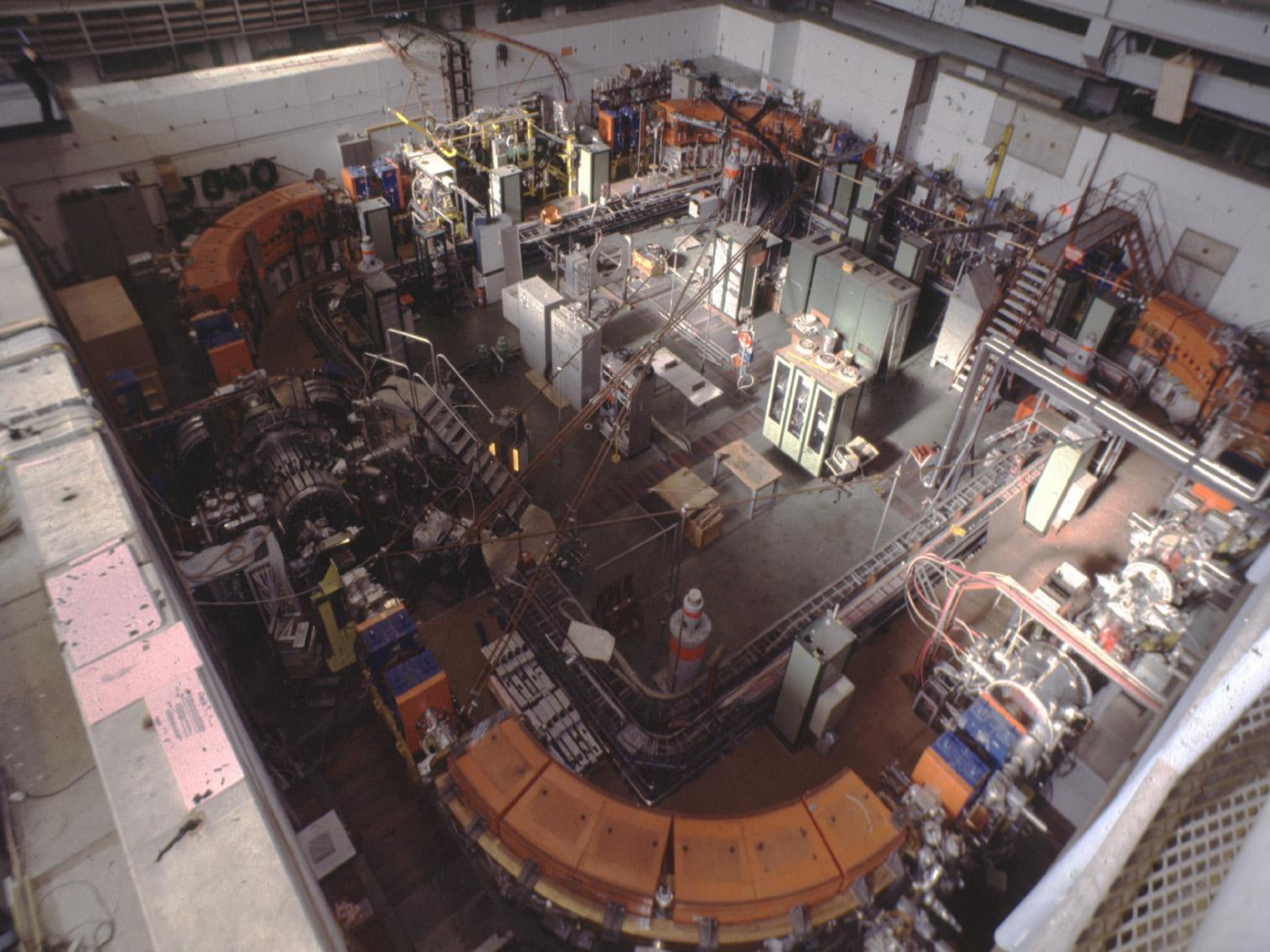
CERN – world biggest accelerator complex

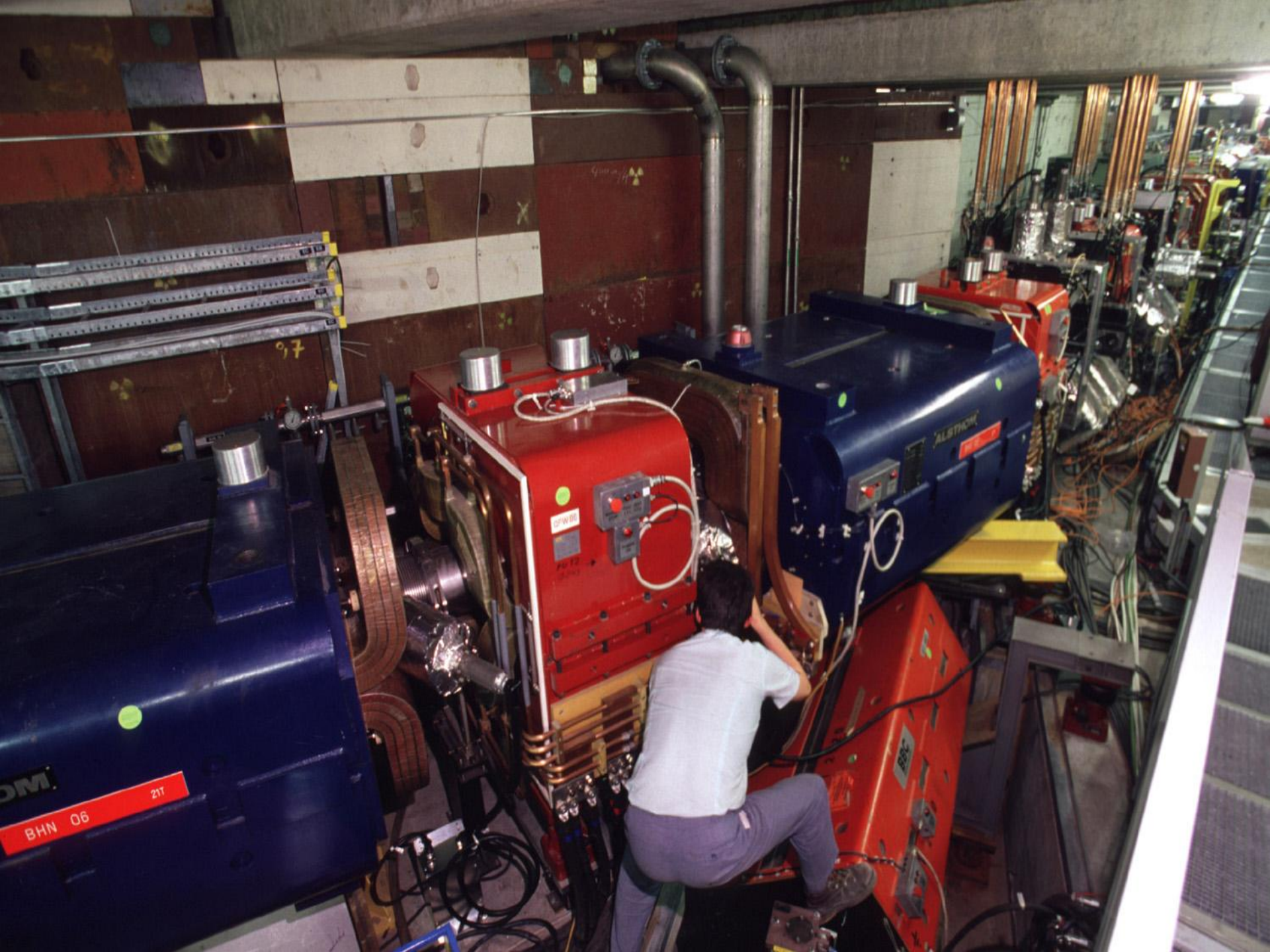


PA 312 3T

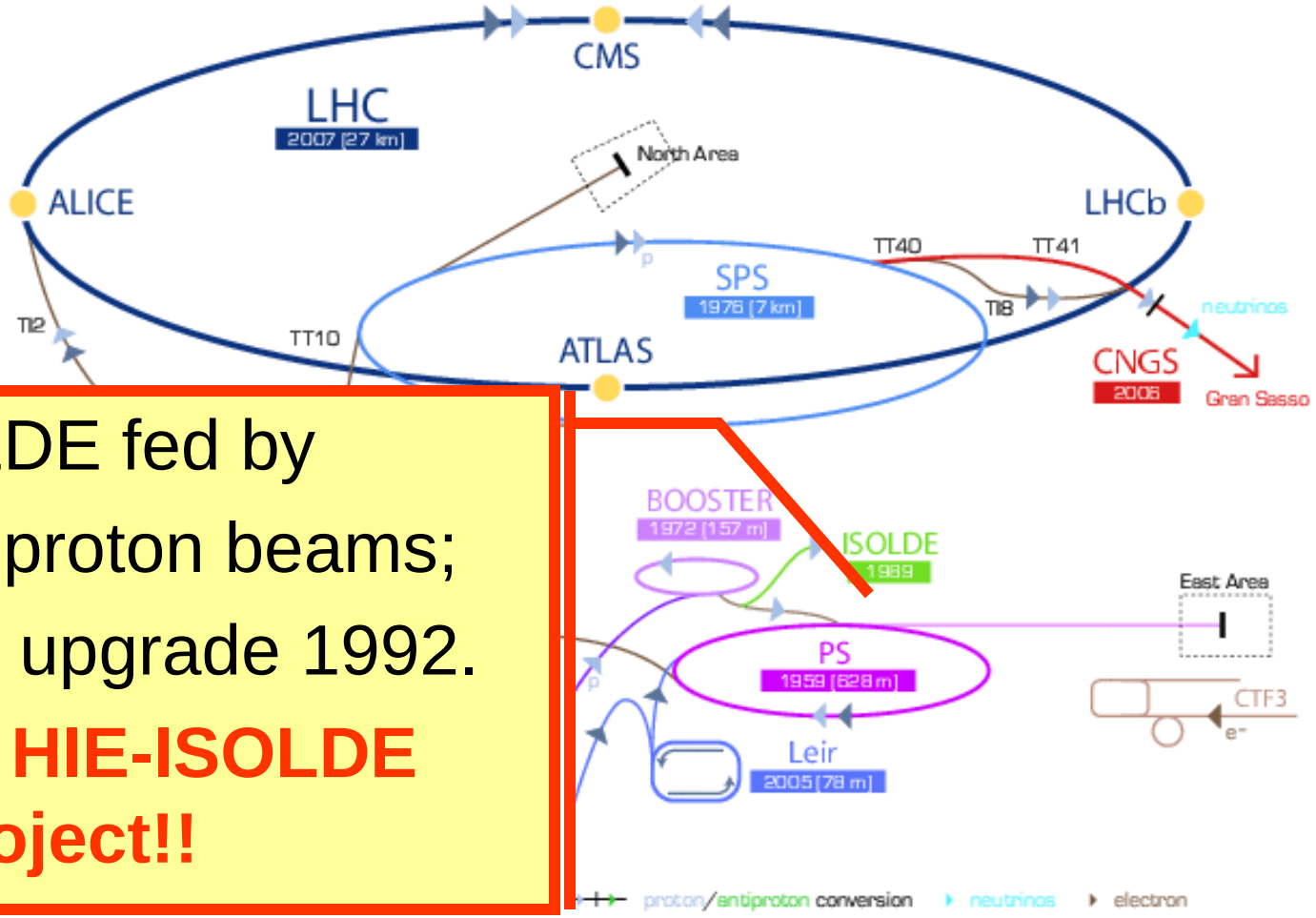
PS - 50
years
of service!!


MB 231




BHN 06
21T
ALSTHOM

CERN accelerator complex,
working not only for LHC



ISOLDE fed by

PSB proton beams;

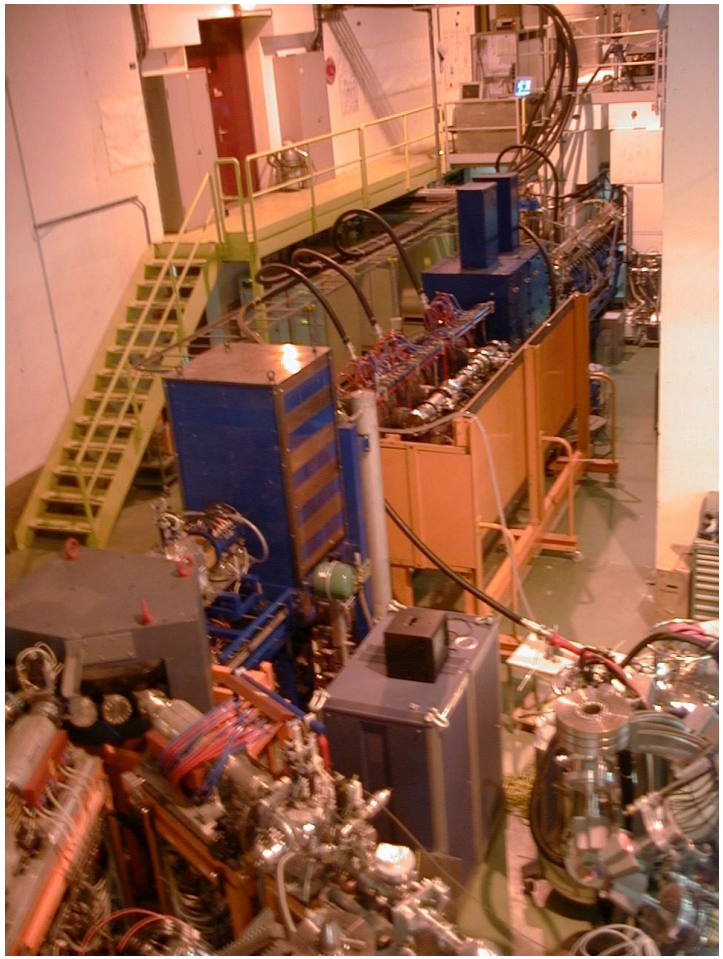
1967 upgrade 1992.

Now HIE-ISOLDE Project!!

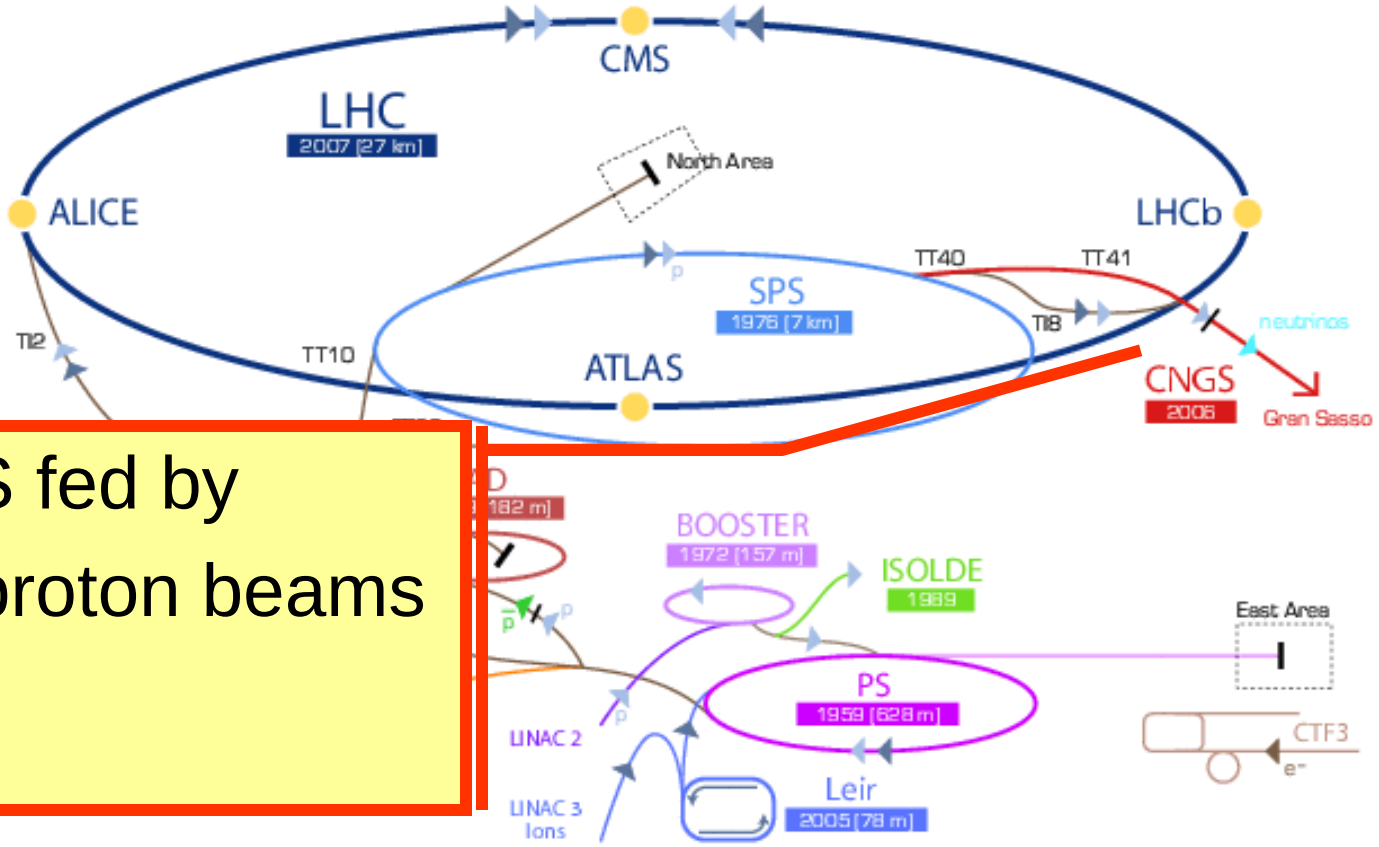
ISOLDE - Isotope Separator On Line, and REX - Radioactive beam EXperiment

An alchemical factory for nuclear physics

Low-energy beams of radioactive isotopes - atomic nuclei. The facility, located at the Proton-Synchrotron Booster (PSB), is like a small alchemical factory, changing one element to another. It produces a total of more than 1000 different isotopes for a wide range of research.



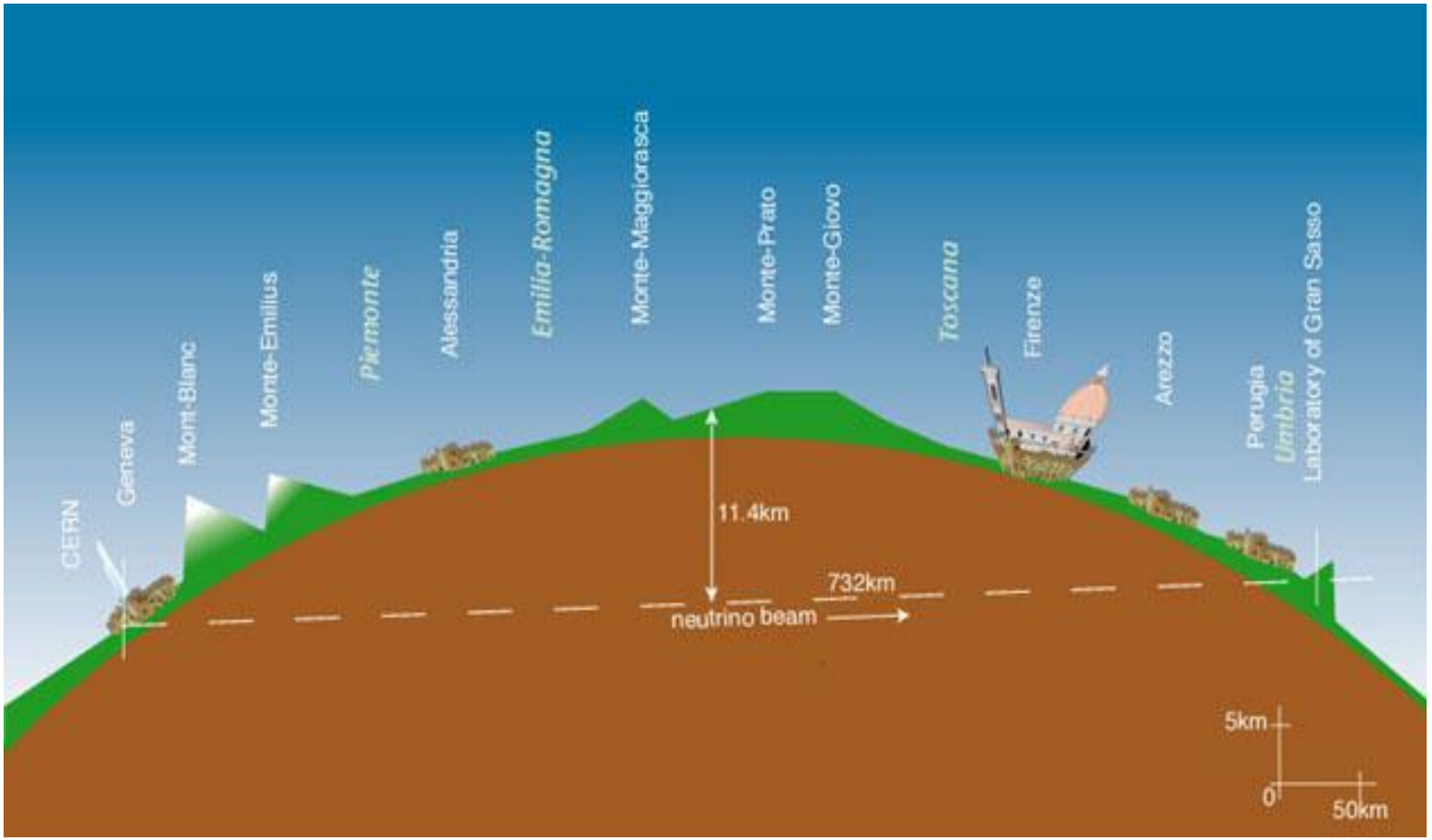
CERN accelerator complex,
working not only for LHC !



CNGS fed by
SPS proton beams

CNGS – CERN Neutrino to Gran Sasso experiment - investigation of the nature of neutrinos

CERN sends muon neutrinos to the Gran Sasso National Laboratory (LNGS), 732 km away in Italy. There, two experiments, OPERA and ICARUS, wait to find out if any of the muon neutrinos have transformed into tau neutrinos. To create the neutrino beam, a proton beam from the Super Proton Synchrotron (SPS) is used.

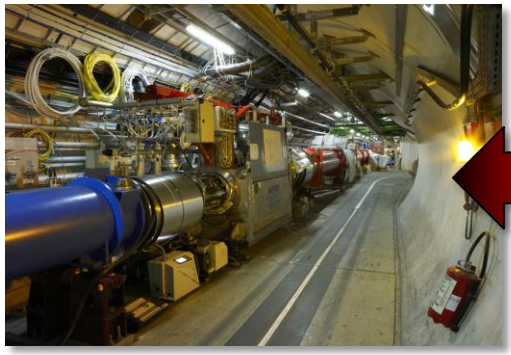


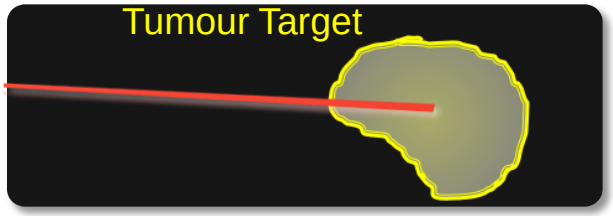
CERN Technologies - Innovation

Example: medical application

Medical imaging

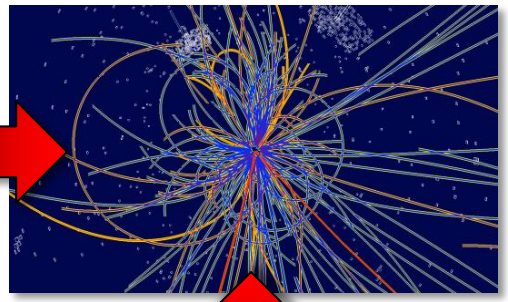
Accelerating particle beams



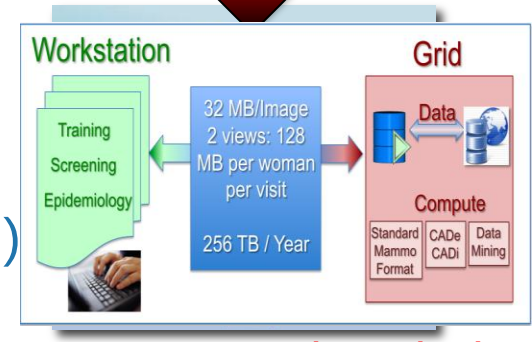


Charged hadron beam that loses energy in matter

Detecting particles



Large-scale **computing** (Grid)



Grid computing for medical data management and analysis

Innovation Education
CERN
uniting people
Research

CERN Technologies and Innovation

Example: Medical applications

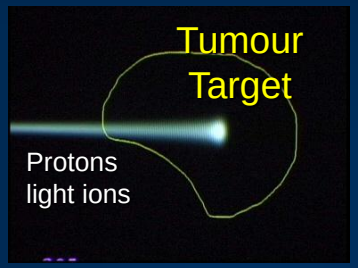
Combining Physics, ICT, Biology and Medicine to fight cancer

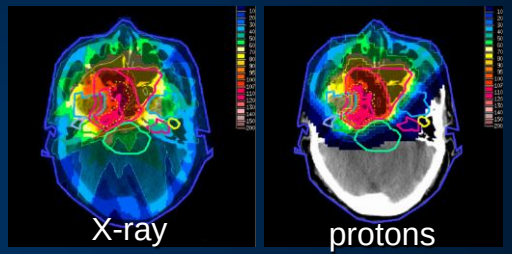
Accelerating particle beams

~30’000 accelerators worldwide

~17’000 used for medicine

Hadron Therapy

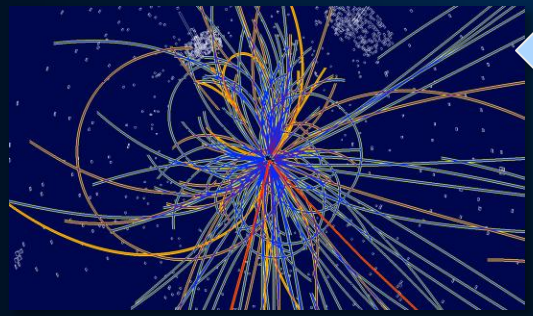




Leadership in Ion Beam Therapy now in Europe and Japan

>70’000 patients treated worldwide (30 facilities)

>21’000 patients treated in Europe (9 facilities)

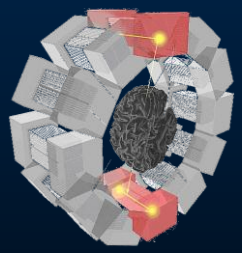


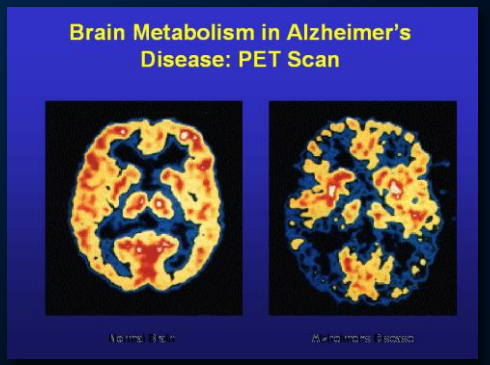
Detecting particles

Imaging

Clinical trial in Portugal for new breast imaging system (ClearPEM)

PET Scanner





CERN Education Activities

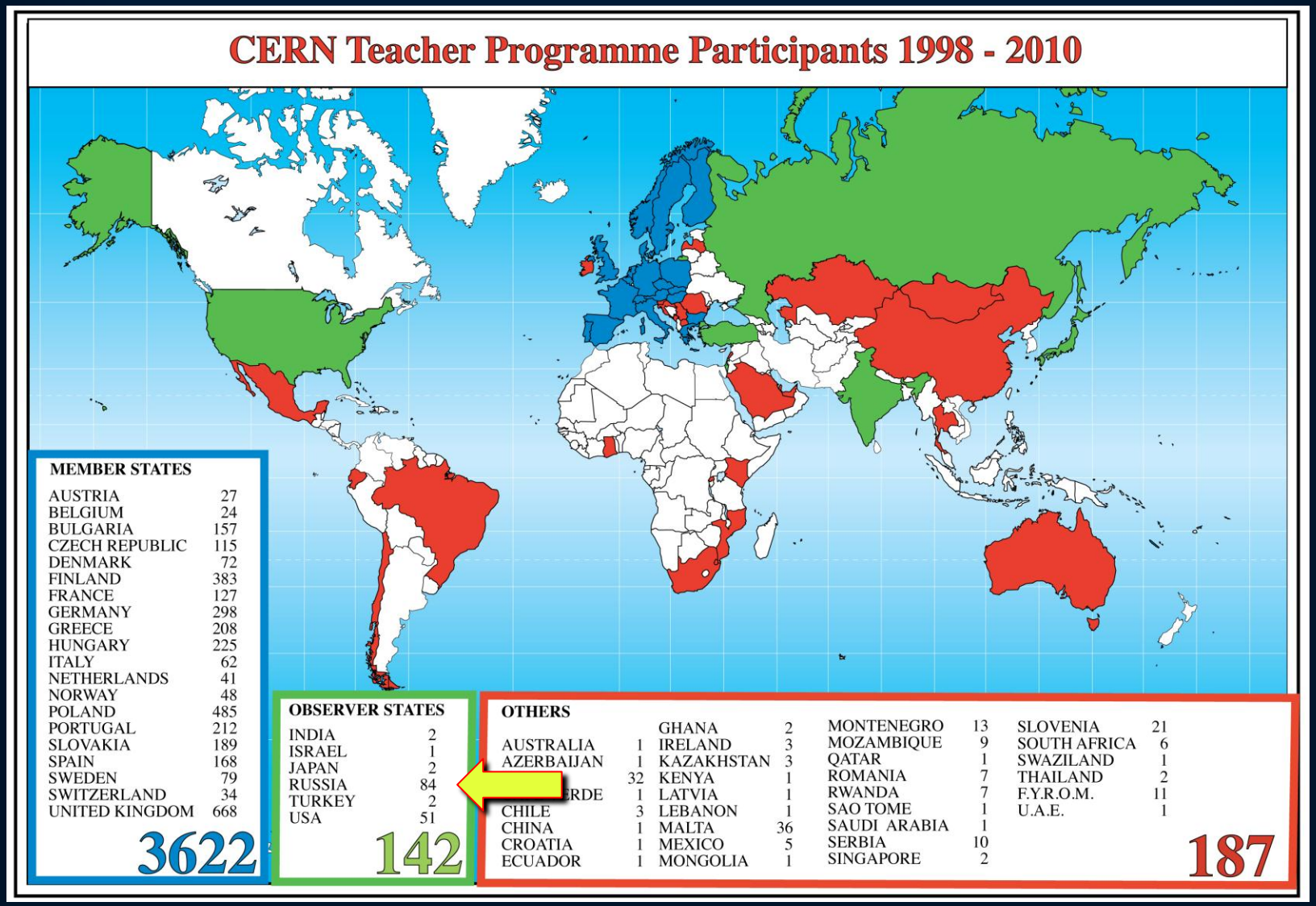
Scientists at CERN
Academic Training Programme

Young Researchers
CERN School of High Energy Physics
CERN School of Computing
CERN Accelerator School

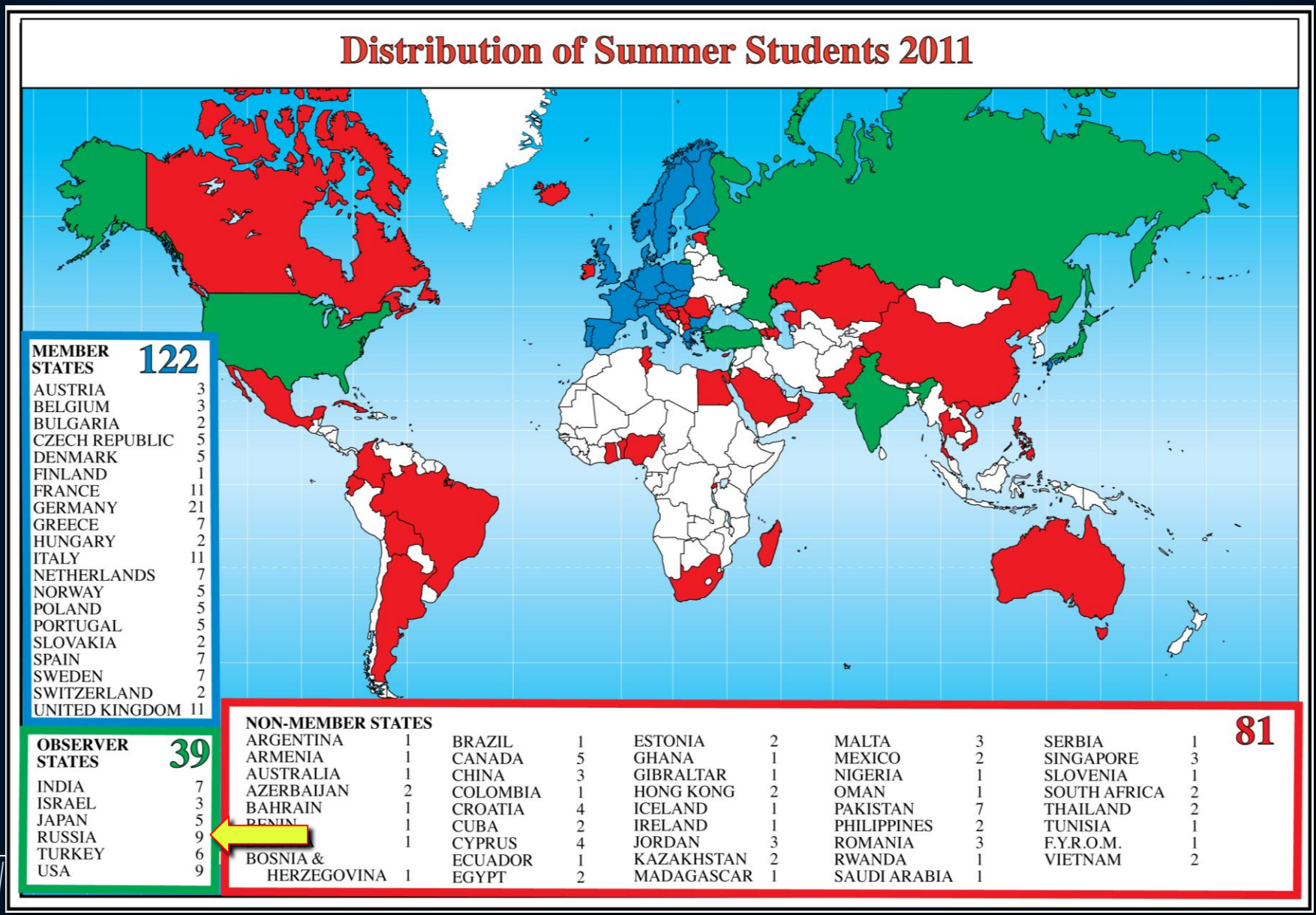
Physics Students
Summer Students Programme

CERN Teacher Schools
International and National Programmes

CERN Teacher Programme



Summer Students 2011



Science Bringing Nations Together

"…the promotion of contacts between scientists, students, engineers…."

Thank you
Спасибо !