UNIVERSITÄT BERN

Prve tri minute

Admir Greljo

Cultural collisions - BiH, 06.11.2020

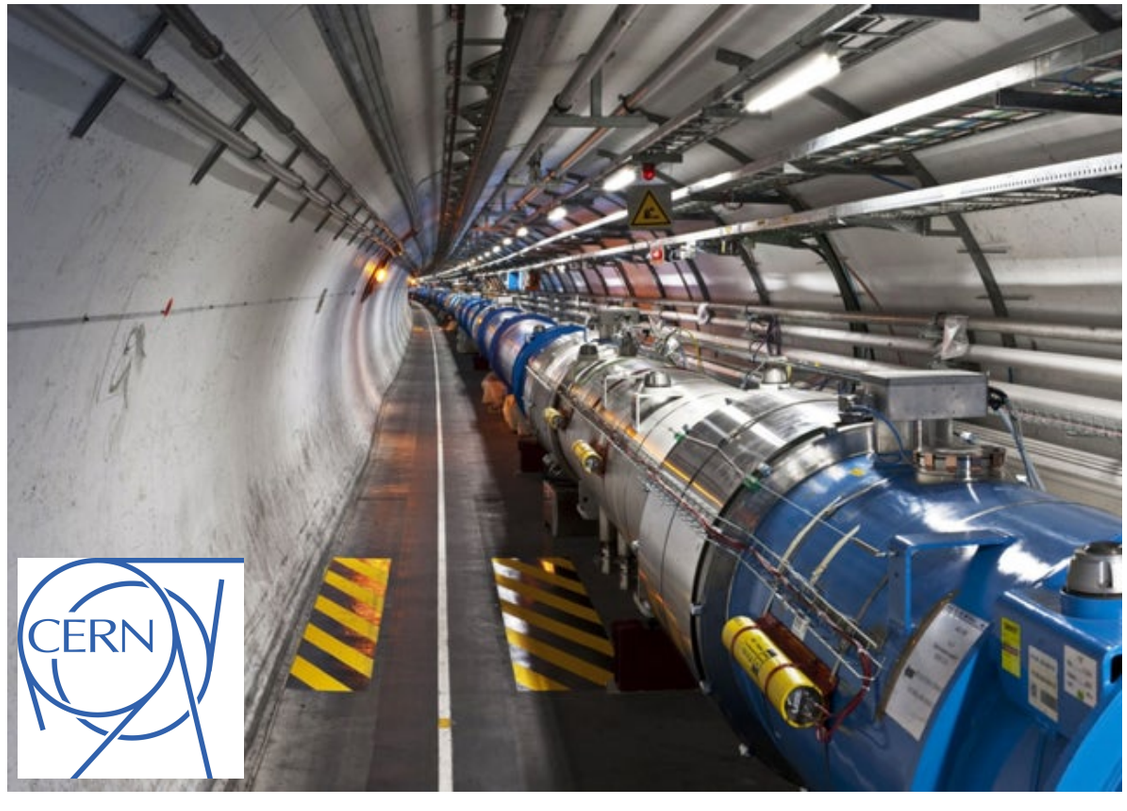
“Grupe i simetrije”

Grupe i simetrije

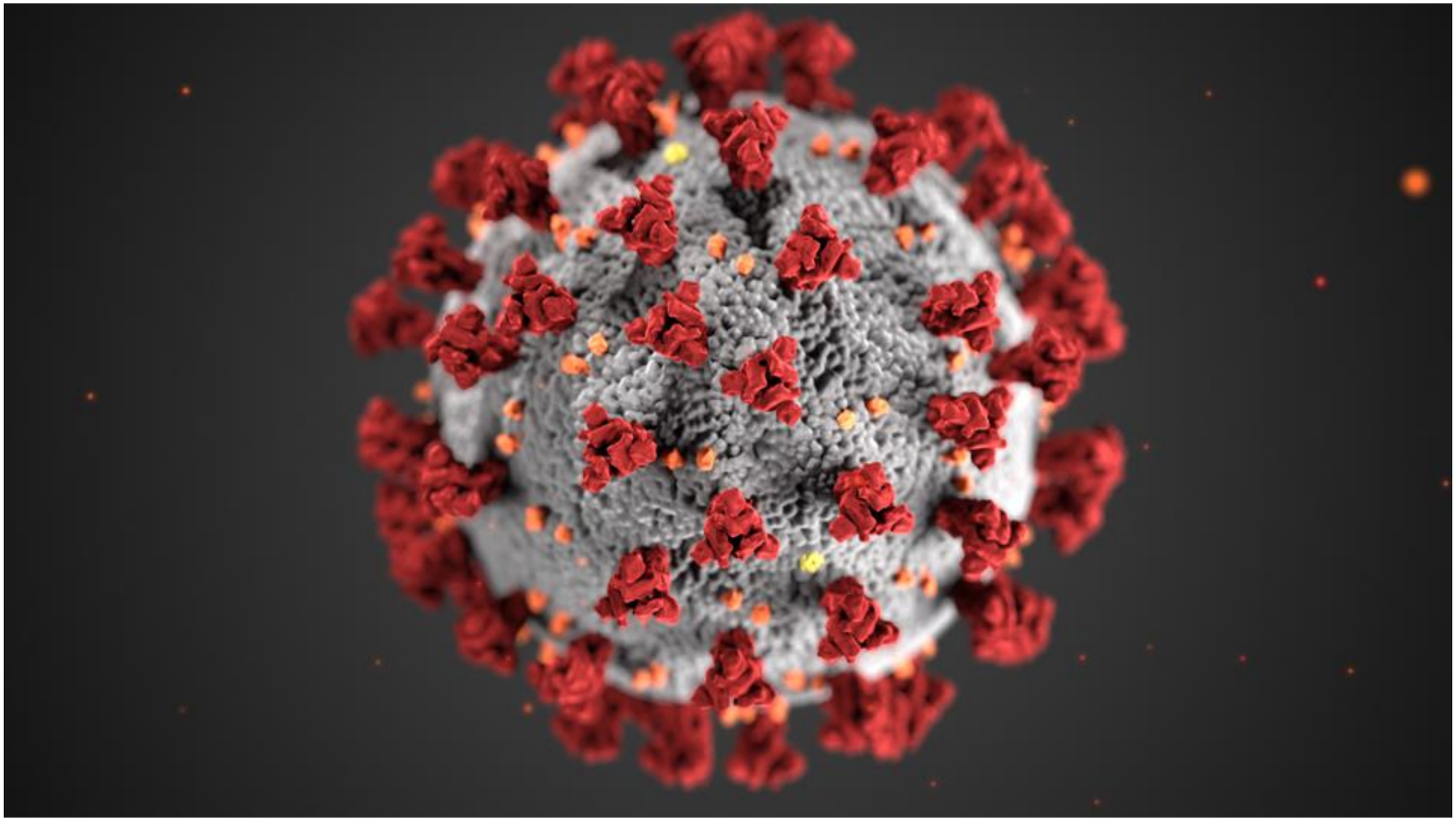
Alhambra, Granada

Od čega je izgrađeno?

. . .



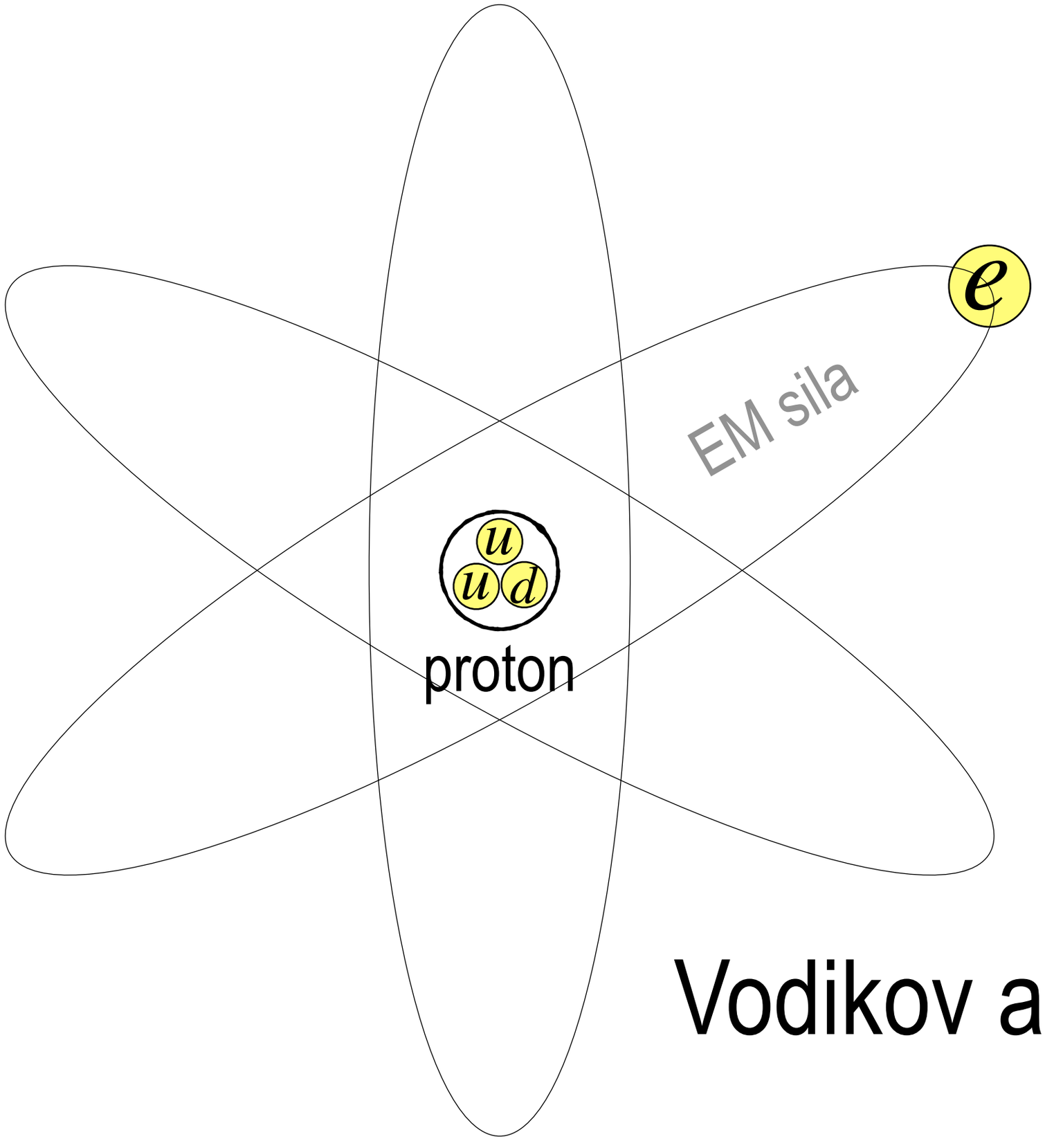
1 metar / 10 **miliona**



SARS-CoV-2

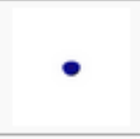
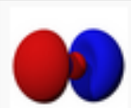
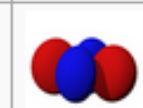
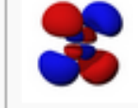
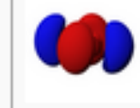
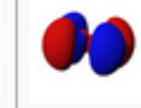
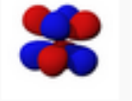
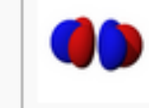
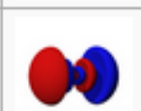
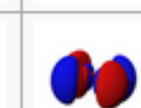
CDC / ALISSA ECKERT & DAN HIGGINS - Electron microscope image

1 metar / 10 **milijardi**



Vodikov atom

1 metar / 10 **milijardi**

	s ($\ell = 0$)	p ($\ell = 1$)			d ($\ell = 2$)					f ($\ell = 3$)						
	$m = 0$	$m = 0$	$m = \pm 1$		$m = 0$	$m = \pm 1$		$m = \pm 2$		$m = 0$	$m = \pm 1$		$m = \pm 2$		$m = \pm 3$	
	s	p_z	p_x	p_y	d_{z^2}	d_{xz}	d_{yz}	d_{xy}	$d_{x^2-y^2}$	f_{z^3}	f_{xz^2}	f_{yz^2}	f_{xyz}	$f_{z(x^2-y^2)}$	$f_{x(x^2-3y^2)}$	$f_{y(3x^2-y^2)}$
$n = 1$																
$n = 2$																
$n = 3$																
$n = 4$																
$n = 5$										...	...	...	...	...	...	...
$n = 6$					...	...	...	...	...	...	...	...	...	...	...	...
$n = 7$		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Vodikov atom

EM sila => Hemija

skupine

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	$^{1}_{1}$H vodik 1,008																	$^{4}_{2}$He helij 4,003
2	$^{7}_{3}$Li litij 6,941	$^{9}_{4}$Be berilij 9,012											$^{11}_{5}$B bor 10,81	$^{12}_{6}$C ugljik 12,01	$^{14}_{7}$N dušik 14,01	$^{16}_{8}$O kisik 16,00	$^{19}_{9}$F fluor 19,00	$^{20}_{10}$Ne neon 20,18
3	$^{23}_{11}$Na natrij 22,99	$^{24}_{12}$Mg magnezij 24,31											$^{27}_{13}$Al aluminij 26,98	$^{28}_{14}$Si silicij 28,09	$^{31}_{15}$P fosfor 30,97	$^{32}_{16}$S sumpor 32,06	$^{35}_{17}$Cl klor 35,45	$^{40}_{18}$Ar argon 39,95
4	$^{39}_{19}$K kalij 39,10	$^{40}_{20}$Ca kalcij 40,08	$^{45}_{21}$Sc skandij 44,86	$^{48}_{22}$Ti titanij 47,90	$^{51}_{23}$V vanadij 50,94	$^{52}_{24}$Cr krom 52,00	$^{55}_{25}$Mn mangan 54,94	$^{56}_{26}$Fe željezo 55,85	$^{59}_{27}$Co kobalt 58,93	$^{58}_{28}$Ni nikal 58,70	$^{63}_{29}$Cu bakar 63,55	$^{64}_{30}$Zn cink 65,38	$^{69}_{31}$Ga galij 69,72	$^{74}_{32}$Ge germanij 72,59	$^{75}_{33}$As arsen 74,92	$^{80}_{34}$Se selenij 78,96	$^{79}_{35}$Br brom 79,90	$^{84}_{36}$Kr kripton 83,80
5	$^{85}_{37}$Rb rubidij 85,47	$^{88}_{38}$Sr stroncij 87,62	$^{89}_{39}$Y itrij 88,91	$^{90}_{40}$Zr cirkonij 91,22	$^{93}_{41}$Nb niobij 92,91	$^{98}_{42}$Mo molibden 95,94	$^{98}_{43}$Tc tehnecij (98)	$^{102}_{44}$Ru rutenij 101,1	$^{103}_{45}$Rh rodij 102,9	$^{106}_{46}$Pd paladij 106,4	$^{107}_{47}$Ag srebro 107,9	$^{114}_{48}$Cd kadmij 112,4	$^{115}_{49}$In indij 114,8	$^{120}_{50}$Sn kositar 118,7	$^{121}_{51}$Sb antimon 121,8	$^{130}_{52}$Te telurij 127,6	$^{127}_{53}$I jod 126,9	$^{129}_{54}$Xe ksenon 131,3
6	$^{133}_{55}$Cs cezij 132,9	$^{138}_{56}$Ba barij 137,3	$^{139}_{57}$La lantan 138,9	$^{180}_{72}$Hf hafnij 178,5	$^{181}_{73}$Ta tantal 180,9	$^{184}_{74}$W volfram 183,9	$^{187}_{75}$Re renij 186,2	$^{192}_{76}$Os osmij 190,2	$^{193}_{77}$Ir iridij 192,2	$^{195}_{78}$Pt platina 195,1	$^{197}_{79}$Au zlato 197,0	$^{202}_{80}$Hg živa 200,6	$^{205}_{81}$Tl talij 204,4	$^{208}_{82}$Pb olovo 207,2	$^{209}_{83}$Bi bizmut 209,0	$^{210}_{84}$Po polonij 209	$^{210}_{85}$At astat 210	$^{222}_{86}$Rn radon 222
7	$^{223}_{87}$Fr francij (223)	$^{226}_{88}$Ra radij 226,0	$^{227}_{89}$Ac aktinij 227,0	$^{261}_{104}$Rf rutherfordij (261)	$^{262}_{105}$Db dubnij (262)	$^{-}_{106}$Sg seaborgij (263)	$^{-}_{107}$Bh bohrij (262)	$^{-}_{108}$Hs hassij (265)	$^{-}_{109}$Mt meitnerij (266)	$^{-}_{110}$Ds darmstadij (271)	$^{-}_{111}$Rg rentgenij (272)	$^{-}_{112}$Cn kopernicij ( )	$^{-}_{113}$Nh nihonij (277)	$^{-}_{114}$Fl flerovij ( )	$^{-}_{115}$Mc moskovij ( )	$^{-}_{116}$Lv livermorij ( )	$^{-}_{117}$Ts tenesin ( )	$^{-}_{118}$Og oganeson (293)

periode

Lantanoidi	$^{140}_{58}$Ce cerij 140,1	$^{141}_{59}$Pr praseodimij 140,9	$^{142}_{60}$Nd neodimij 144,2	$^{146}_{61}$Pm prometij (145)	$^{152}_{62}$Sm samarij 150,4	$^{153}_{63}$Eu europij 152,0	$^{158}_{64}$Gd gadolinij 157,3	$^{159}_{65}$Tb terbij 158,9	$^{164}_{66}$Dy disprozij 162,5	$^{165}_{67}$Ho holmij 164,9	$^{166}_{68}$Er erbij 167,3	$^{169}_{69}$Tm tulij 168,9	$^{174}_{70}$Yb iterbij 173,0	$^{175}_{71}$Lu lutecij 175,0
Aktinoidi	$^{232}_{90}$Th torij (232)	$^{231}_{91}$Pa protaktinij (231)	$^{238}_{92}$U uranij (238)	$^{237}_{93}$Np neptunij (237)	$^{244}_{94}$Pu plutonij (244)	$^{243}_{95}$Am americij (243)	$^{247}_{96}$Cm kurij (247)	$^{247}_{97}$Bk berkelij (247)	$^{251}_{98}$Cf kalifornij (251)	$^{254}_{99}$Es einsteinij (252)	$^{257}_{100}$Fm fermij (257)	$^{258}_{101}$Md mendelevij (258)	$^{259}_{102}$No nobelij (259)	$^{260}_{103}$Lr lawrencij (262)

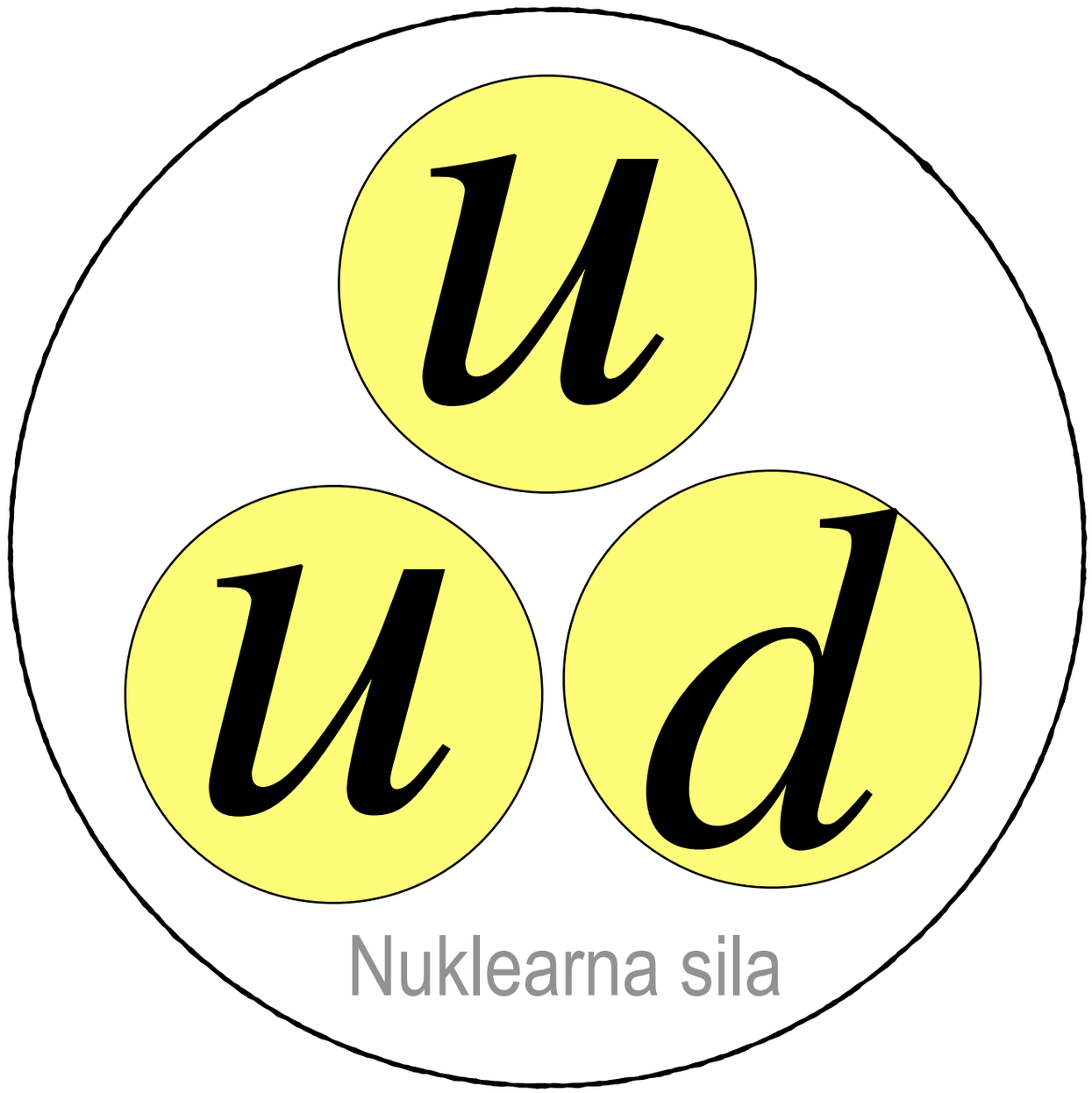
$^{A}_{Z}$X
ime
A_r

A – nukleonski broj najčešćega izotopa
Z – protonski broj
A_r – relativna atomska masa

metali nemetali polumetali

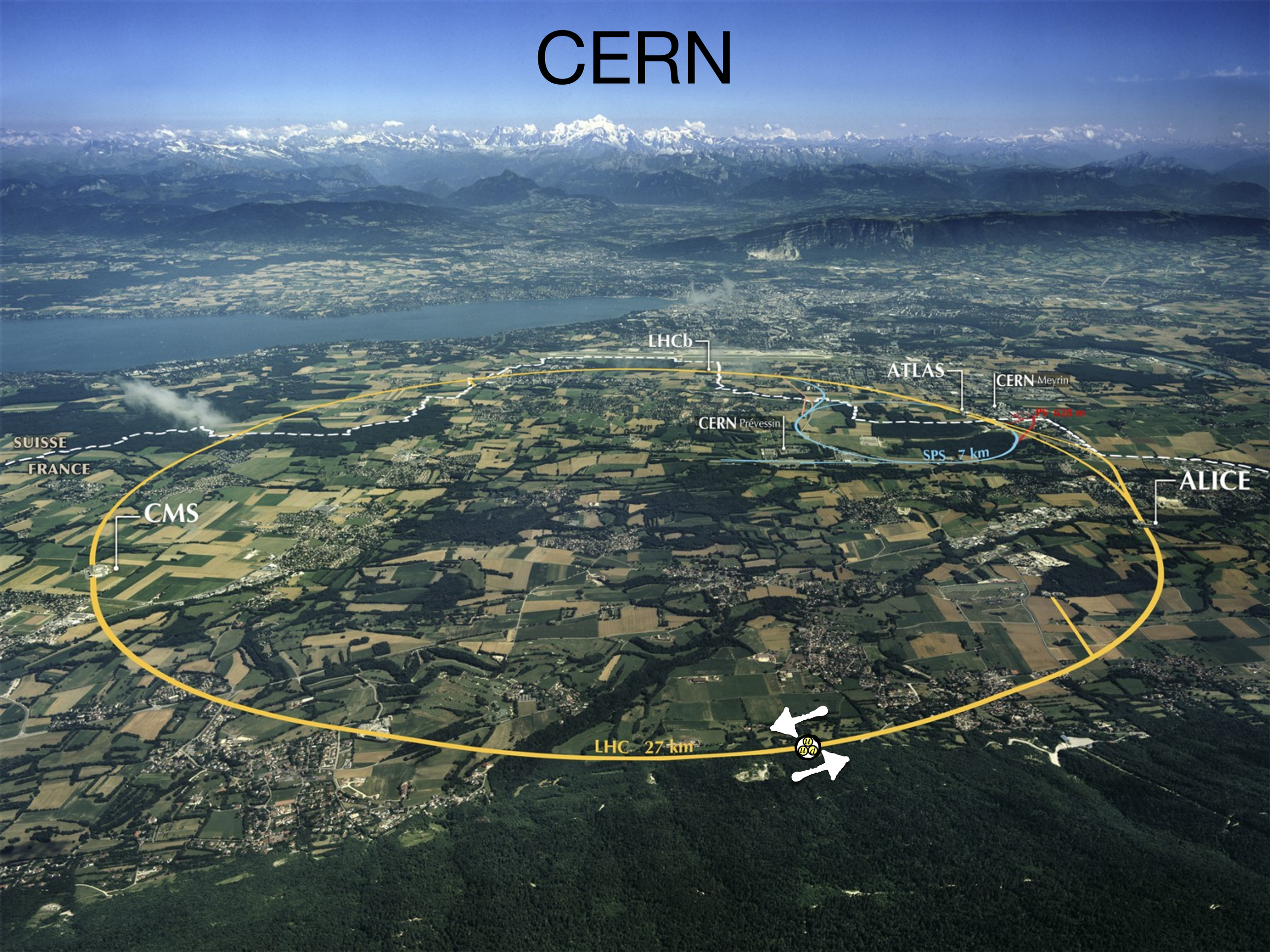
- Šarolikost svijeta se svodi na konačan broj elemenata koji vole da se druže (hemijske reakcije)

1 metar / **milion milijardi**

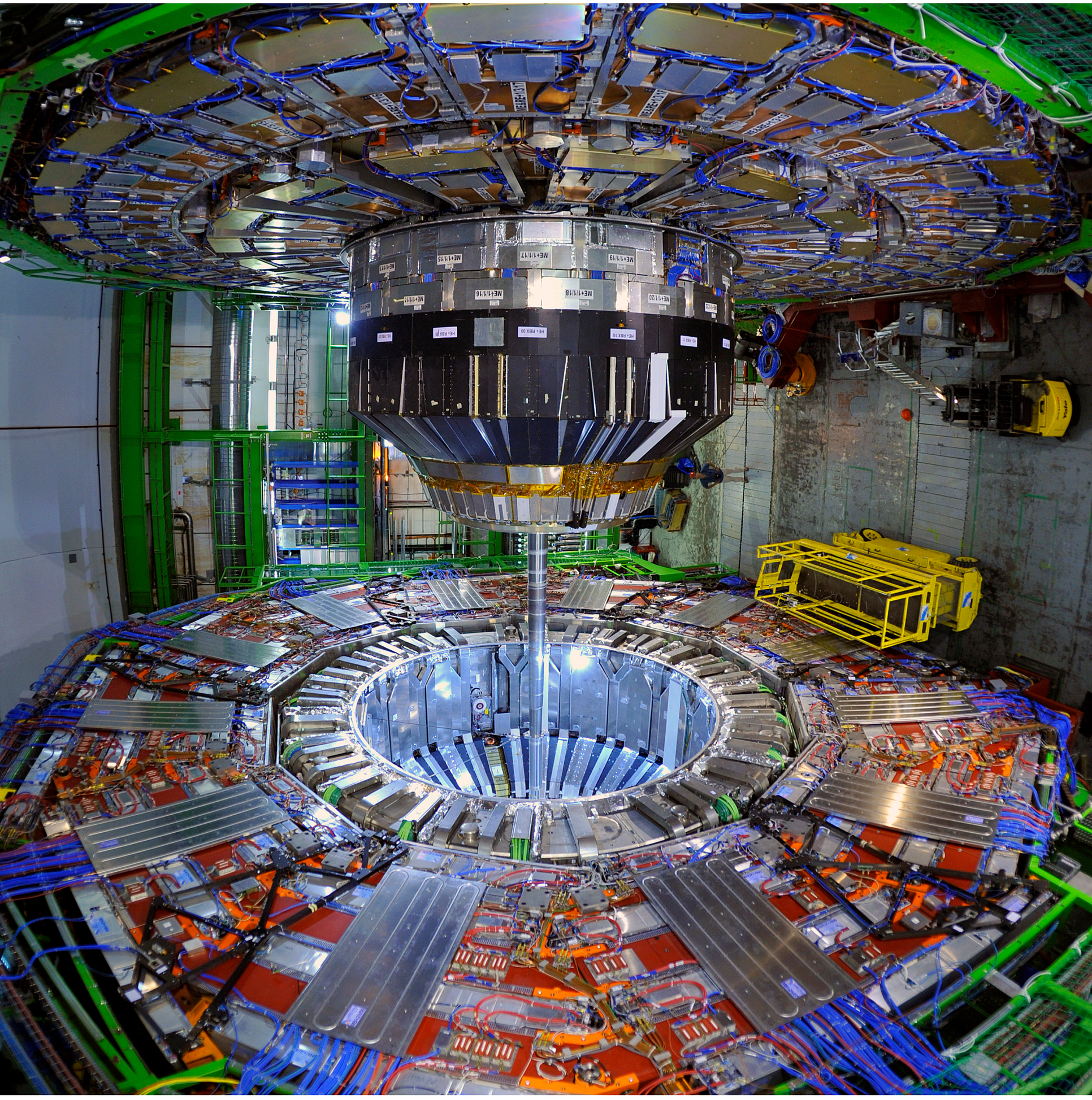


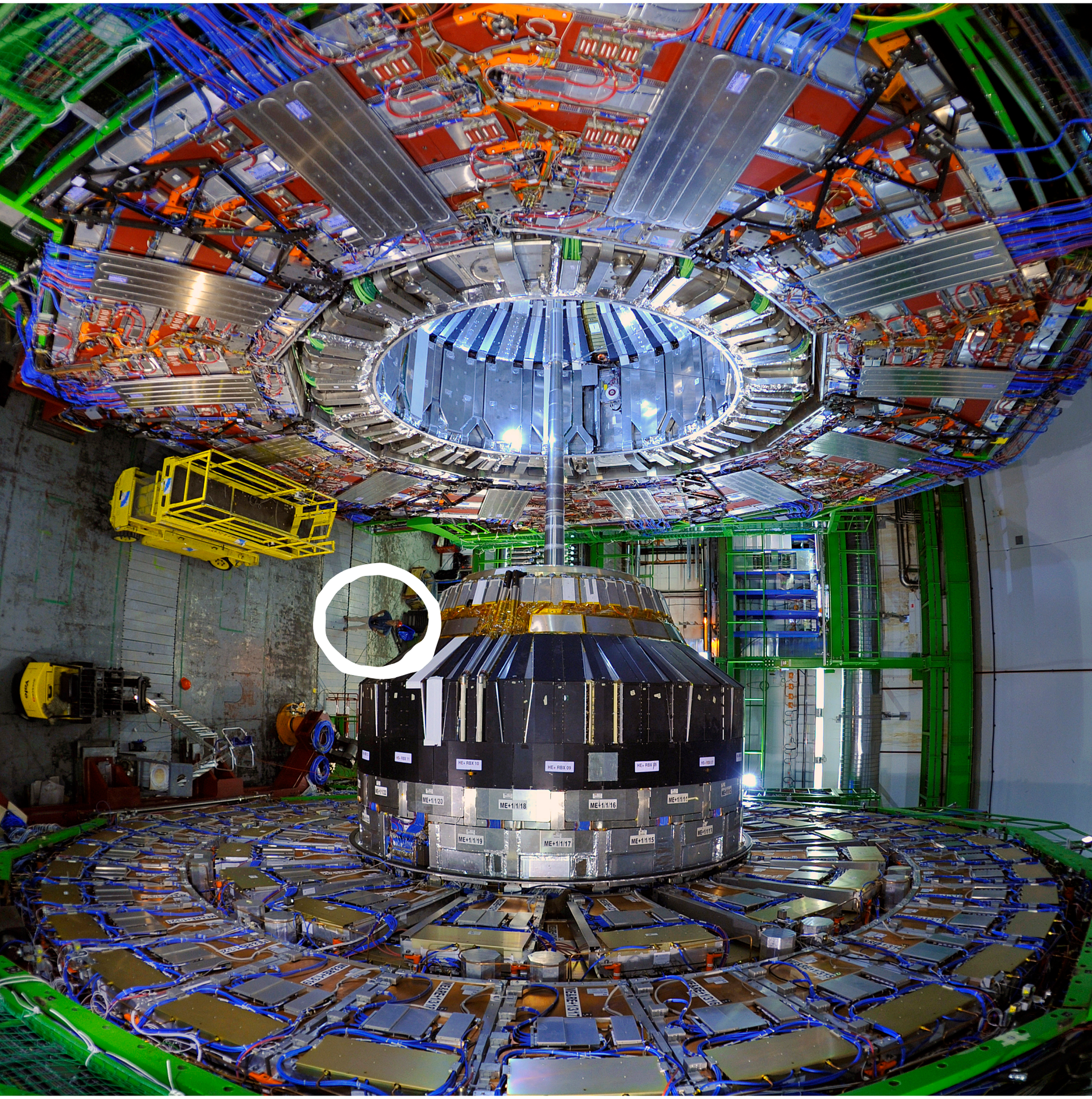
Proton

CERN


LHCb
ATLAS
CERN Meyrin
PS 628 m
CERN Prévessin
SPS 7 km
SUISSE
FRANCE
ALICE
CMS
LHC 27 km

Veliki hadronski sudarivač (LHC)


ME+1/1/15
ME+1/1/17
ME+1/1/19
ME+1/1/16
ME+1/1/18
ME+1/1/20
HE+ RBX 09
HE+ RBX 10


ME+1/1/20
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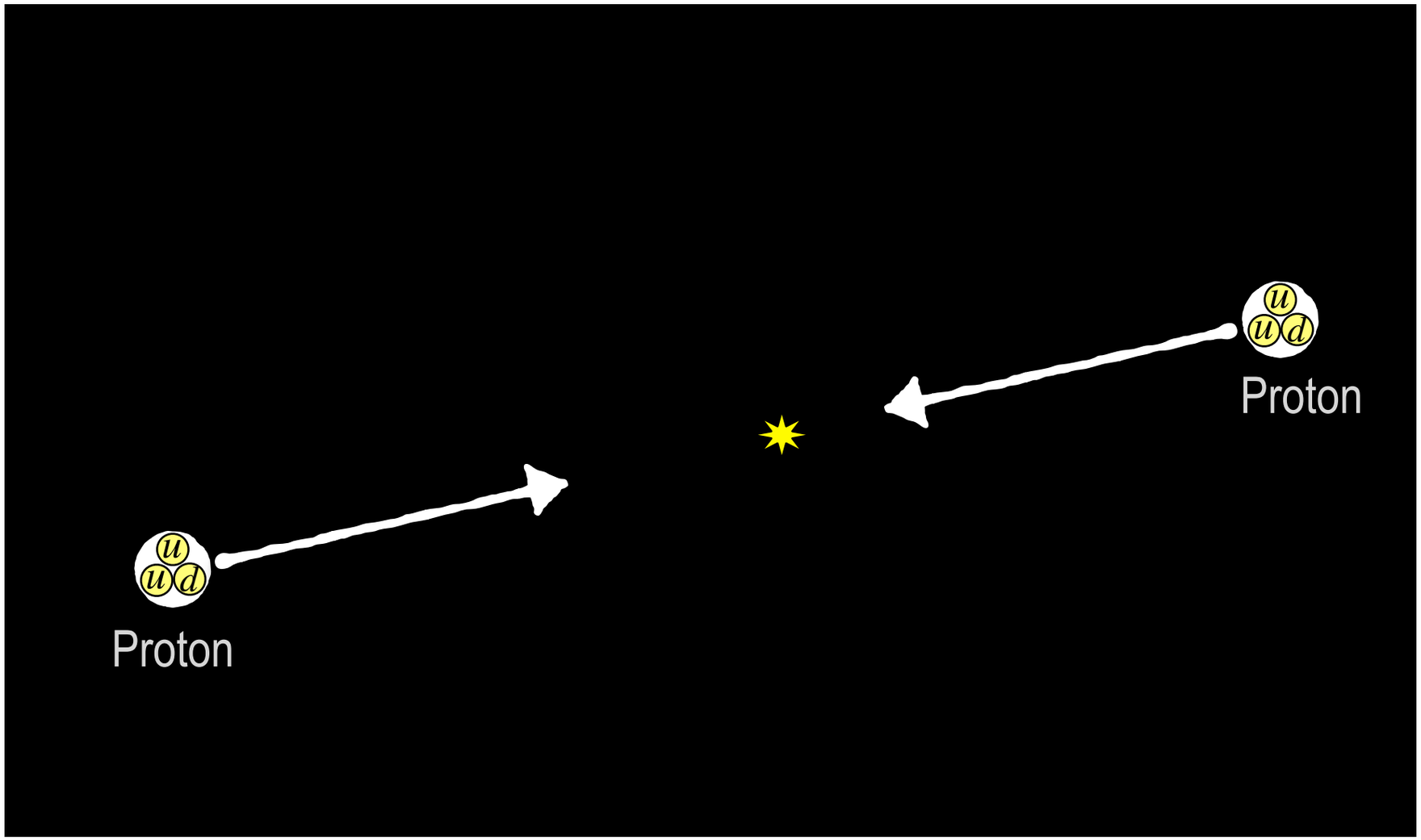
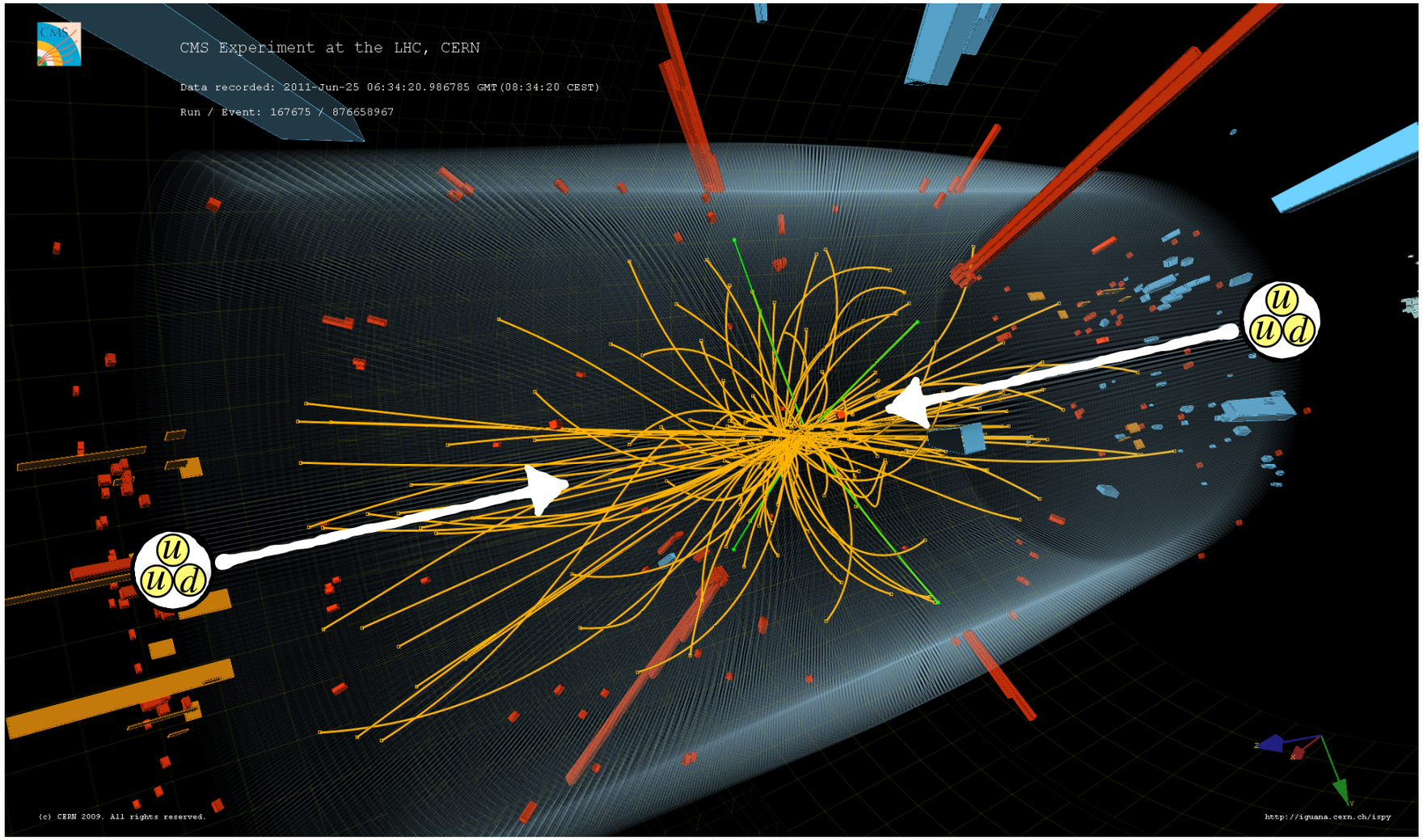
ME+1/1/16
ME+1/1/19
ME+1/1/17
ME+1/1/15

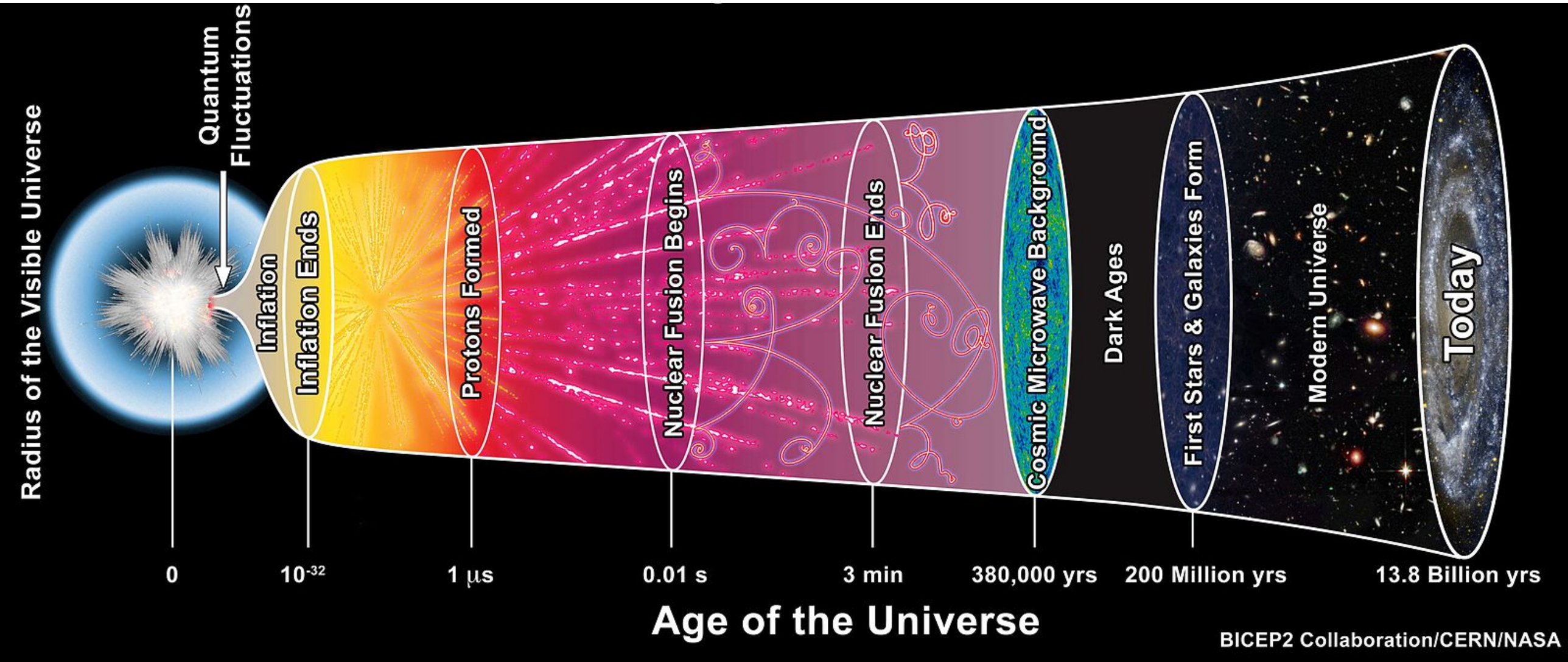
www.annt.ba

Prvi bosanskohercegovački CERN-ov program za profesore, februar 2020

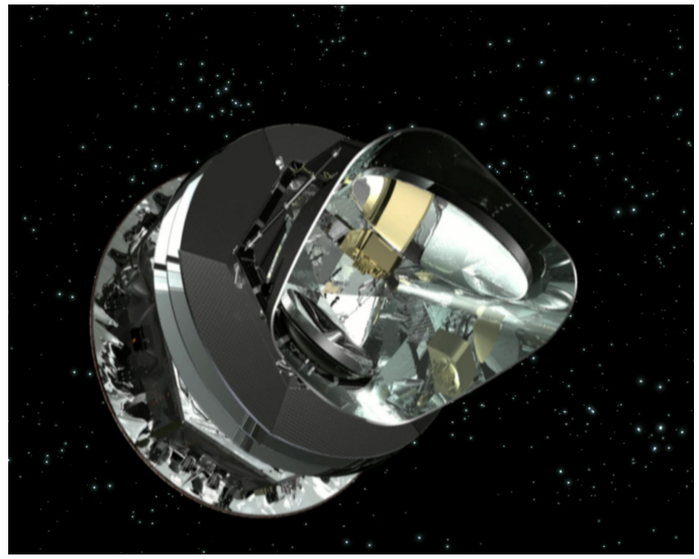


Brzina protona 99.9999991% brzine svjetlosti


CMS Experiment at the LHC, CERN
Data recorded: 2011-Jun-25 06:34:20.986785 GMT(08:34:20 CEST)
Run / Event: 167675 / 876658967
u
u
d
u
u
d
(c) CERN 2009. All rights reserved.
http://iguana.cern.ch/ispy


Quantum Fluctuations
Radius of the Visible Universe
Inflation
Inflation Ends
Protons Formed
Nuclear Fusion Begins
Nuclear Fusion Ends
Cosmic Microwave Background
Dark Ages
First Stars & Galaxies Form
Modern Universe
Today
0
10-32
1 μs
0.01 s
3 min
380,000 yrs
200 Million yrs
13.8 Billion yrs
Age of the Universe
BICEP2 Collaboration/CERN/NASA

ESA, Planck



Radius of the Visible Universe

Quantum Fluctuations

Inflation

Inflation Ends

Protons Formed

Nuclear Fusion Begins

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Cosmic Microwave Background

Dark Ages

First Stars & Galaxies Form

Modern Universe

Today

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10^{-32}

1 μs

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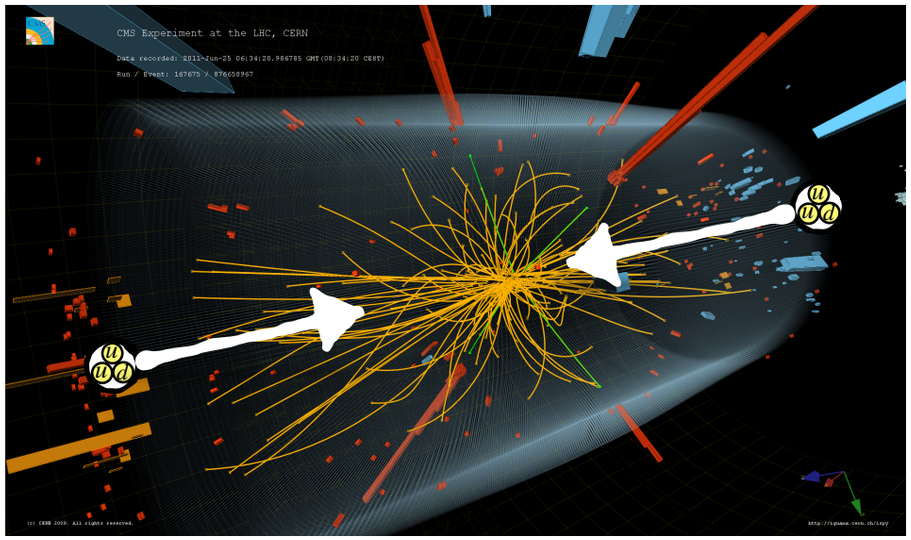
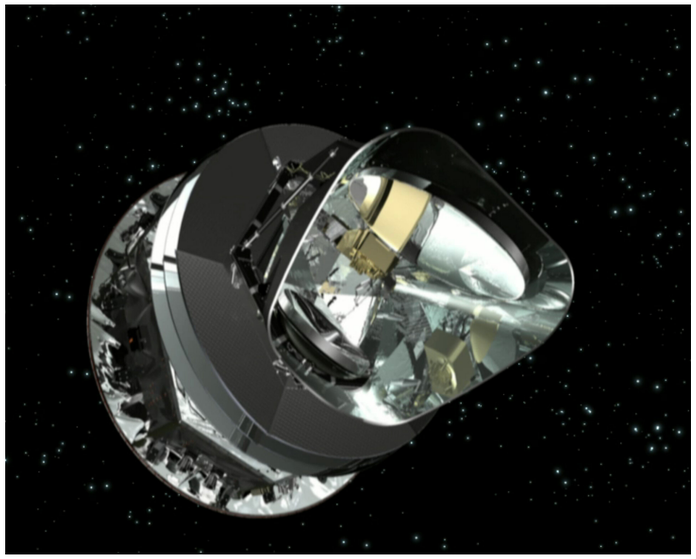
Age of the Universe

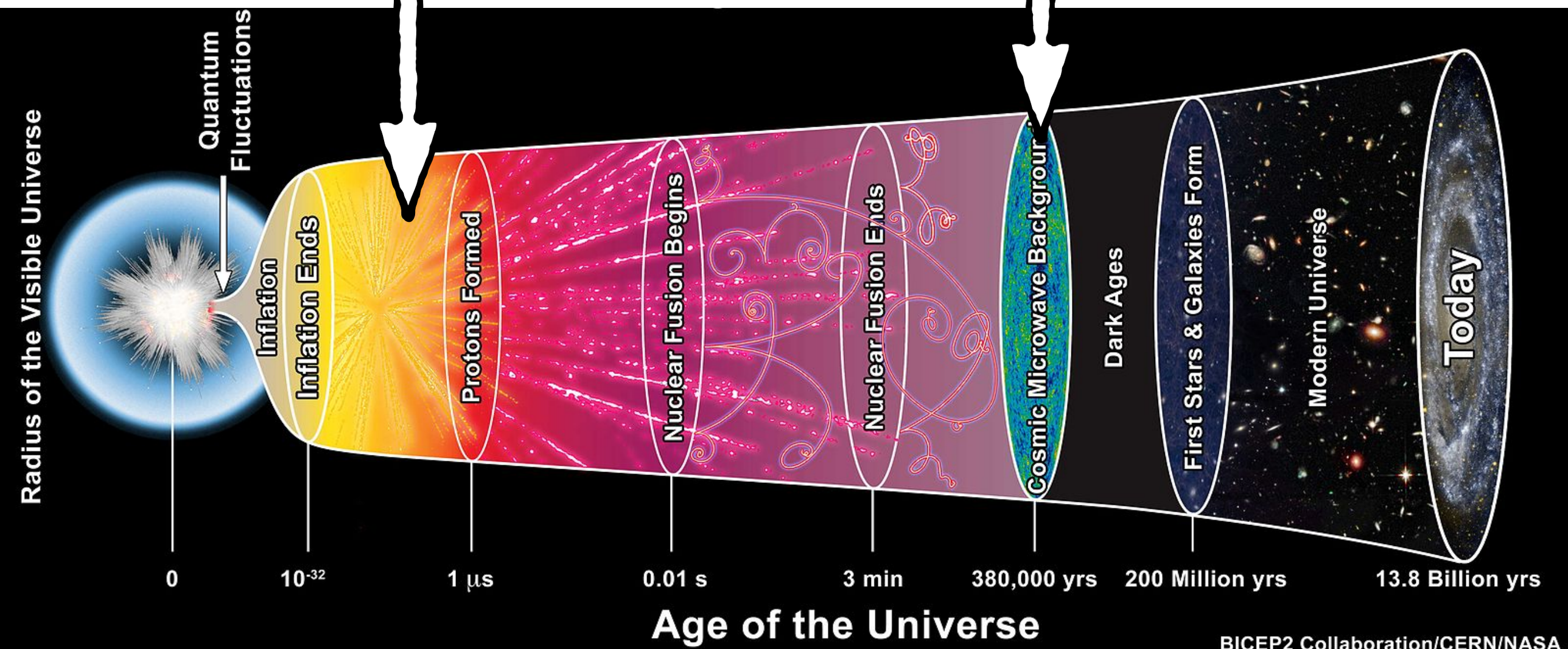
BICEP2 Collaboration/CERN/NASA

LHC



ESA, Planck



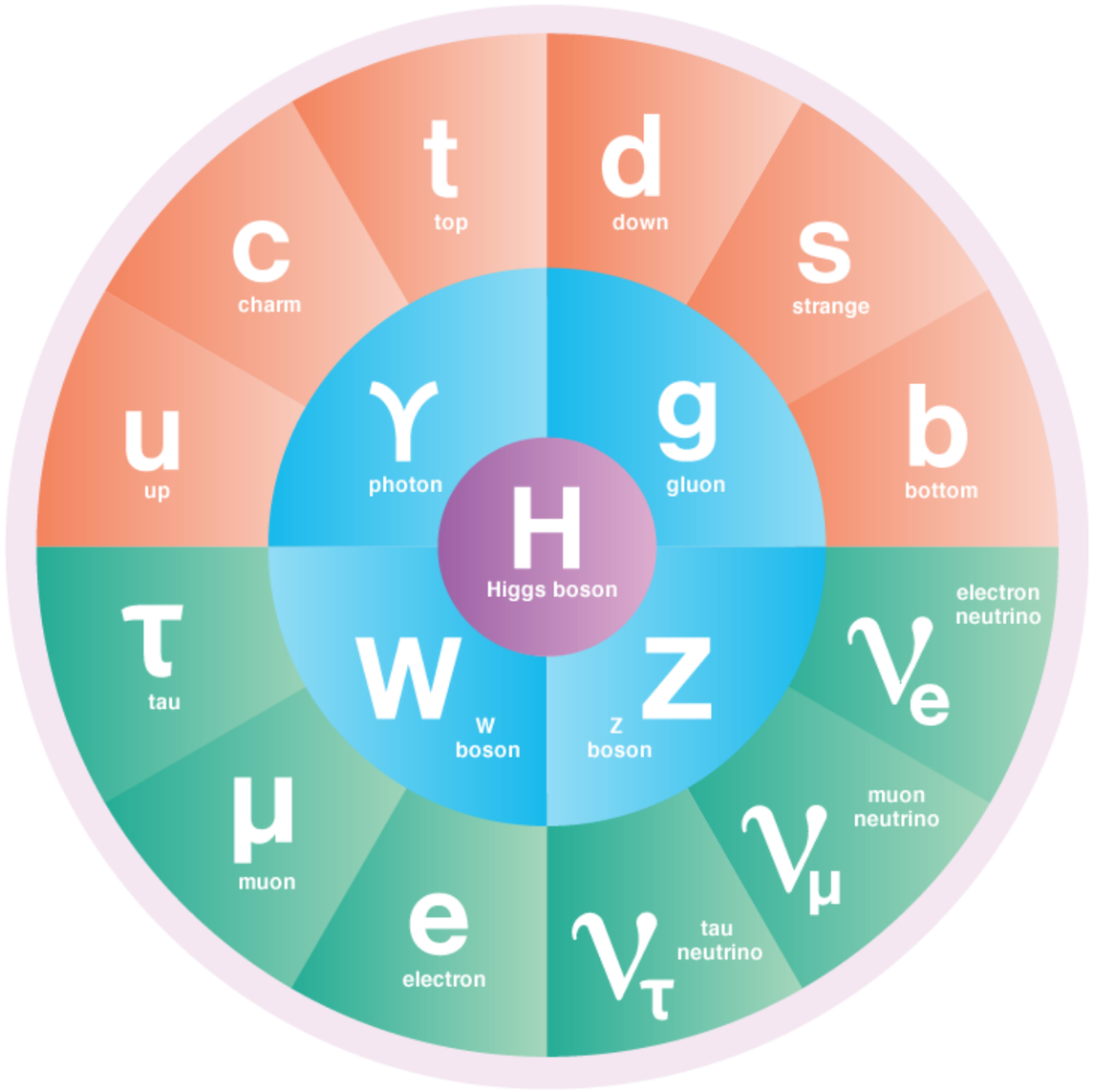


Od čega je izgrađeno?

… pomaže da razumijemo sami početak

Standardni Model

Teorija EM i nuklearnih sila



- Grupa simetrije
  => osobine i interakcije čestica

HISTORY OF THE UNIVERSE

Dark energy accelerated expansion

Structure formation

Cosmic Microwave Background radiation is visible

Accelerators

RHIC & LHC heavy ions

LHC protons

High-energy cosmic rays

Size of visible universe

TODAY

Inflation

Big Bang

POSSIBLE DARK MATTER RELICS

NUCLEONS FORM

NUCLEI FORM

$t = 10^{-36}$ s
$E = 10^{16}$ GeV

$t = 10^{-10}$ s
$E = 10^{2}$ GeV

$t = 10^{-4}$ s
$E = 10^{-1}$ GeV

$t = 10^{2}$ s
$E = 10^{-4}$ GeV

$t = 3 \times 10^{5}$ y
$E = 3 \times 10^{-10}$ GeV

$t = 10^{9}$ y
$E = 10^{-12}$ GeV

$t = 13.8 \times 10^{9}$ y
$E = 2.3 \times 10^{-13}$ GeV

t = Time (seconds, years)

E = Energy of photons (units GeV = 1.6 x 10^{-10} joules)

Key

- quark
- gluon
- electron
- muon
- tau
- neutrino
- bosons
- meson
- baryon
- ion
- atom
- photon
- star
- galaxy
- black hole

The concept for the above figure originated in a 1986 paper by Michael Turner.

Supported by DOE

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NUCLEI FORM

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$E = 10^{2}$ GeV

$t = 10^{-4}$ s
$E = 10^{-1}$ GeV

$t = 10^{2}$ s
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POSSIBLE DARK MATTER RELICS

NUCLEONS FORM

NUCLEI FORM

2

$t = 10^{-36}$ s
$E = 10^{16}$ GeV

$t = 10^{-10}$ s
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POSSIBLE DARK MATTER RELICS

NUCLEONS FORM

NUCLEI FORM

3

$t = 10^{-36}$ s
$E = 10^{16}$ GeV

$t = 10^{-10}$ s
$E = 10^{2}$ GeV

$t = 10^{-4}$ s
$E = 10^{-1}$ GeV

$t = 10^{2}$ s
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$t = 3 \times 10^{5}$ y
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Key

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Supported by DOE

Rani svemir: Prva lekcija

1

t = 1 sekund / 10 **milijardi**

- Dramatičan događaj! Fazni prelaz!
- EM sila se razvodi od slabe nuklearne!
- Prostor postaje ispunjen Higgsovim poljem!
- Elementarne Čestice dobiju masu!

Higgsovo polje

Top kvark / Masa 173 GeV

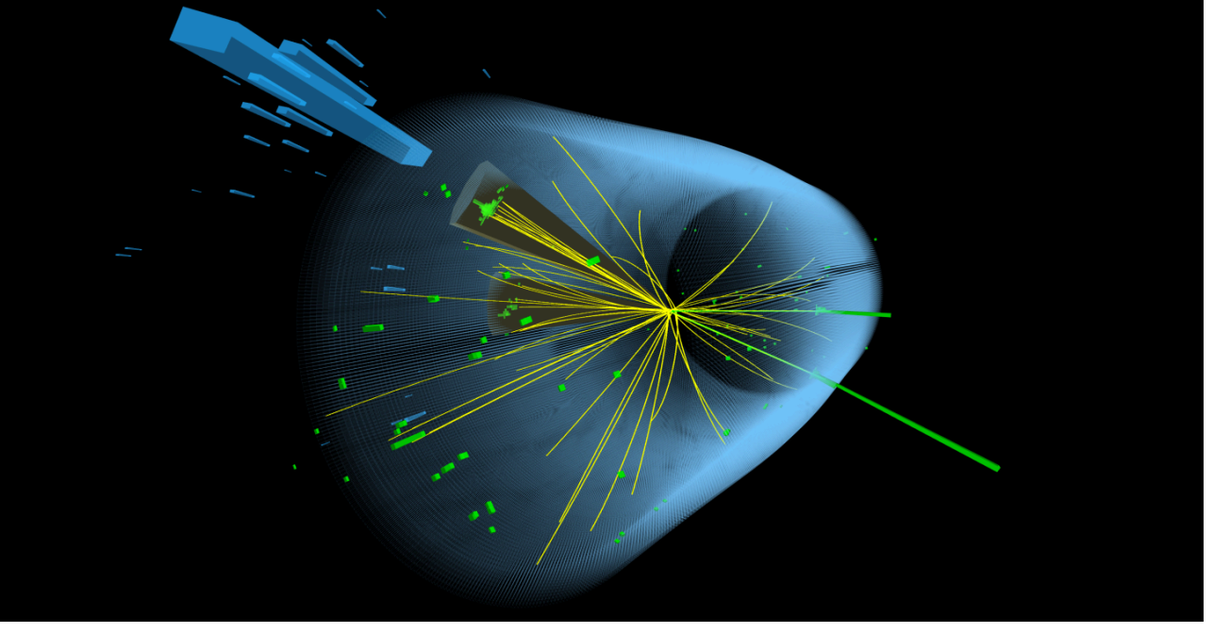
Top kvark / Masa 173 GeV

Up kvark / Masa 0.002 GeV

Up kvark / Masa 0.002 GeV


Eto Edina!

Higgsov bozon



Otkriće Higgsovog bozona

CERN 2012

CERN

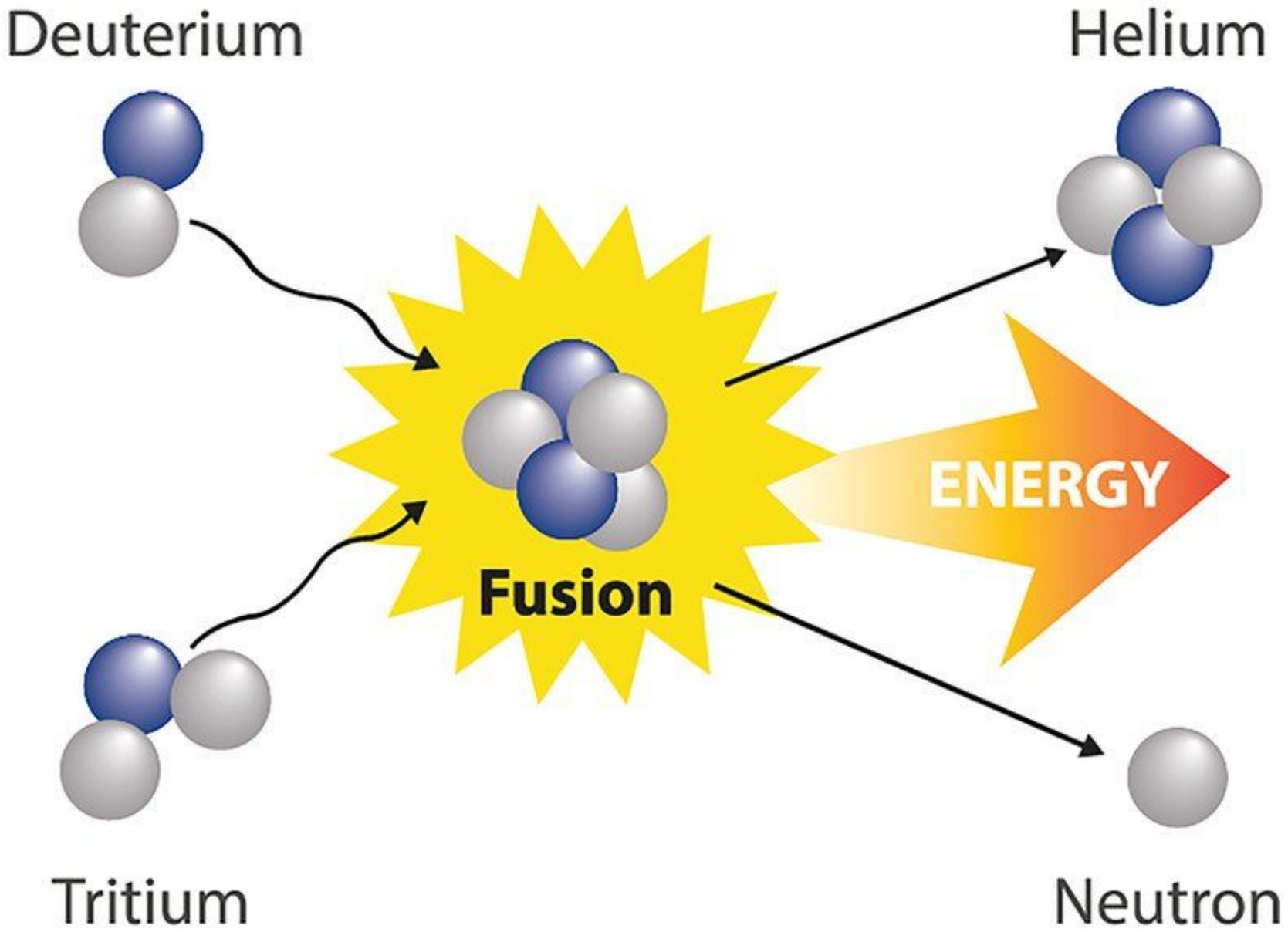
Rani svemir: Druga lekcija

2

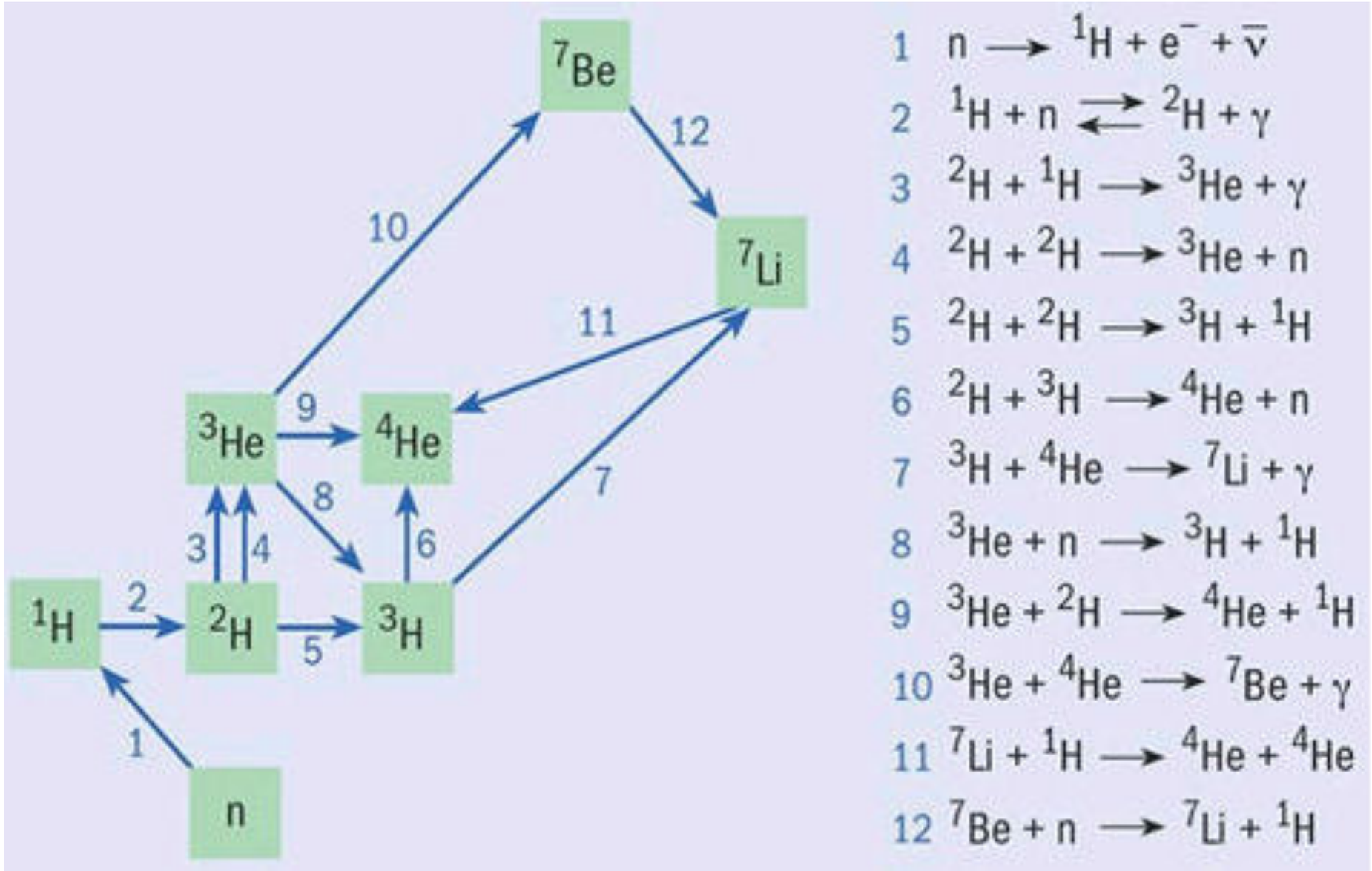
t = 1 sekund / 10 **miliona**

- Dramatičan događaj! Fazni prelaz!
- Kondenzacija jake nuklearne sile!
- Nastaju protoni i neutroni, srce materije!
- Svi su nastali u djeliću prve sekunde postojanja!

Slijedi nukleosinteza…



Slijedi nukleosinteza…



1 $n \longrightarrow {}^{1}H + e^{-} + \bar{\nu}$

2 ${}^{1}H + n \rightleftarrows {}^{2}H + \gamma$

3 ${}^{2}H + {}^{1}H \longrightarrow {}^{3}He + \gamma$

4 ${}^{2}H + {}^{2}H \longrightarrow {}^{3}He + n$

5 ${}^{2}H + {}^{2}H \longrightarrow {}^{3}H + {}^{1}H$

6 ${}^{2}H + {}^{3}H \longrightarrow {}^{4}He + n$

7 ${}^{3}H + {}^{4}He \longrightarrow {}^{7}Li + \gamma$

8 ${}^{3}He + n \longrightarrow {}^{3}H + {}^{1}H$

9 ${}^{3}He + {}^{2}H \longrightarrow {}^{4}He + {}^{1}H$

10 ${}^{3}He + {}^{4}He \longrightarrow {}^{7}Be + \gamma$

11 ${}^{7}Li + {}^{1}H \longrightarrow {}^{4}He + {}^{4}He$

12 ${}^{7}Be + n \longrightarrow {}^{7}Li + {}^{1}H$

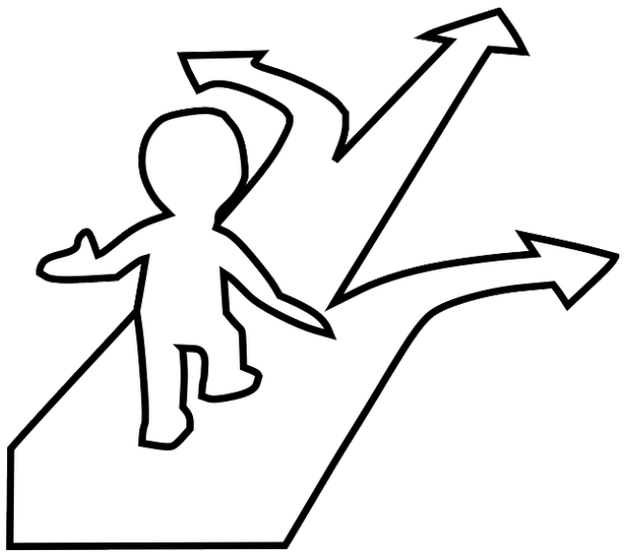
Rani svemir: Treća lekcija

t = 3 minute

- Primordijalna nukleosinteza!
- Nastaju lahki elementi, npr. većina He!
- Koristeći SM možemo izračunat njihovu količinu!
- Račun se slaže s opservacijama astrofizičara!
- :)

… no, kako do samog početka?

Izvan SM?

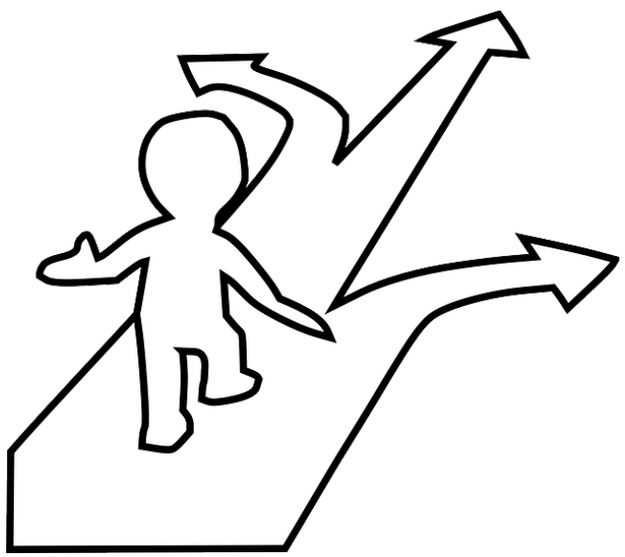


… no, kako do samog početka?

Izvan SM?

Otvorena pitanja:

- Higgsova masa,
- Kvantizacija naelektrisanja
- Porijeklo generacija
- Porijeklo tamne materija
- Imbalans materije/antimaterije
- Mase neutrina
- QCD CP problem,
- Inflacija,
- Kosmološka konstanta,
- Kvantna gravitacija…



… no, kako do samog početka?

Kolika je kosmološka konstanta?

Pitajte teorijskog fizičara:

Reći će:

To je parametar teorije, ali u jedinicama Plankove mase očekujem kvantne korekcije, dakle:

1.0

Kolika je kosmološka konstanta?

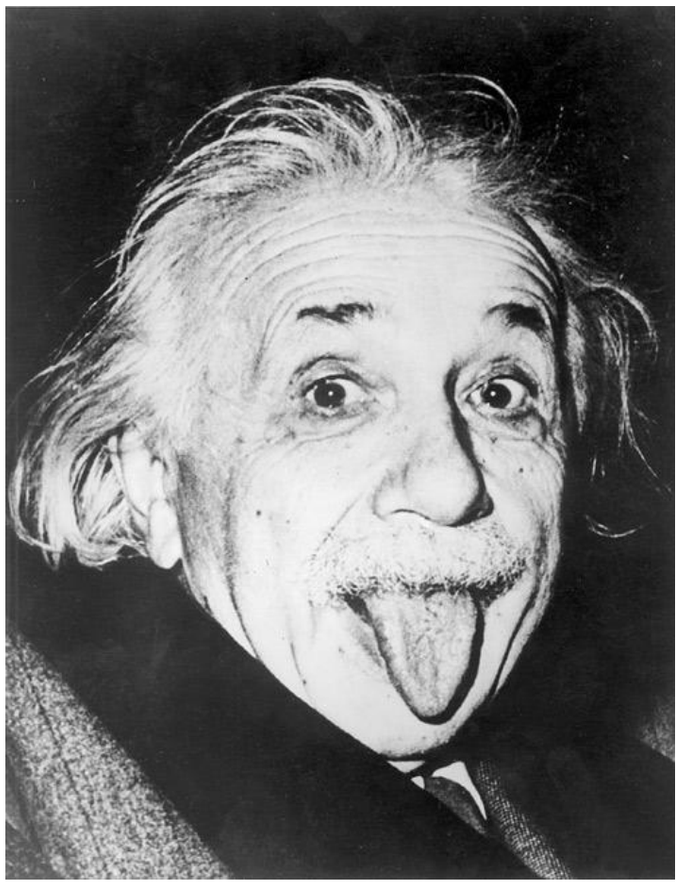
Pitajte eksperimentalce:

Reći će:

Gustoća energije vakuma? Mi smo je izmjerili!

0.000000000000000000000000000000000000000
000000000000000000000000000000000000000000
000000000000000000000000000000000000000001

Dakle, kosmološka konstanta je najveća blamaža u teorijskoj fizici.



$$R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} + \Lambda\, g_{\mu\nu} = 8\pi G\, T_{\mu\nu}$$

Teorijski fizičar iz drugog pokušaja:

1.00000000000000000000000000000000000000000
0000000000000000000000000000000000000000000
0000000000000000000000000000000000000001
-
1.0

“kvantne korekcije”

Fino podešavanje

PHYSICAL REVIEW LETTERS

Anthropic Bound on the Cosmological Constant

Steven Weinberg
Phys. Rev. Lett. **59**, 2607 – Published 30 November 1987

ABSTRACT

In recent cosmological models, there is an "anthropic" upper bound on the cosmological constant Λ. It is argued here that in universes that do not recollapse, the only such bound on Λ is that it should not be so large as to prevent the formation of gravitationally bound states. It turns out that the bound is quite large. A cosmological constant that is within 1 or 2 orders of magnitude of its upper bound

- Zakoni fizike u našem svemiru su “fino podešeni” što omogućava postojanje nas!

?

Od čega je izgrađeno?

UNIVERSITÄT BERN